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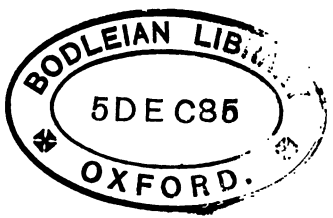
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PREFACE TO FOURTH EDITION.

A FOURTH edition of this little book having been called for, a few introductory remarks are necessary to call attention to the changes which will be found in it.

Though the general plan of the work remains the same, much of the old matter has been rearranged, and a large addition of new information has been made; the whole work has also been thoroughly revised and brought up to date.

In the older editions many items had wandered away from their proper sections, and this, in a compilation treating on so many different subjects and derived from so many different sources, is perhaps unavoidable at first; the opportunity has now been taken to gather all the stray facts together under their respective headings. This has altered the appearance of the book considerably; but it is hoped that it will facilitate the work of reference. Considerable pains have also been taken to make the Index thoroughly comprehensive, so that the Sailor should quickly be able to find an answer to any question he might put to the book.

The principal additions are: in Section I., notices of the weather signals adopted by various foreign countries; for these I have to thank Lieutenant Baillie of the Meteorological Office. Much more complete information on the International Code of signals is also given than before. In Section II., Sir William Thomson's compass is fully described, aided by drawings kindly

furnished by the inventor. In Section III., some practical and simple rules for avoiding collisions at sea, by Vice-Admiral de Horsey, have been introduced. The admiral has also kindly placed at my disposal some notes on boat sailing, which will be found in Section VI. By far the most important addition, however, is the section devoted to steam: this has been written for the Pocket Book by Mr. Yeo, Chief Engineer, R.N., the Instructor of Steam at the Royal Naval College, Greenwich, who has devoted much time and thought to it; and Mr. Rudd, Engineer, R.N., who was associated with him at the college for some time, has also assisted. The illustrations are from photographs of original drawings taken by Mr. Haddon of the Royal Naval College.

It has again happened that my duties have called me from England while this edition has been passing through the press, and once more my old friend Commander Thomas A. Hull, R.N., late Superintendent of Admiralty Charts, has undertaken the onerous task of revising and correcting; this is sufficient guarantee for its having been thoroughly done. Commander Hull has added considerably to the passage tables, and also introduced the star maps, which will be found useful and less confusing than many larger publications.

The Foreign sea terms and phrases have been carefully revised by Commander C. R. Harris, and German has been added, corrected by Lieutenant H.S.H. Prince Louis of Battenberg, R.N. The Italian portion was also revised, by Captain Grenet (of the *Italia*, R.I.N.).

I can hardly hope that this edition will find more favour with seafaring people than those which have preceded it; but I trust that the alterations and additions will be recognized as an earnest endeavour to keep the *Sailor's Pocket Book* up to date.

F. G. D. B.

H.M.S. *Monarch*,
ALEXANDRIA, *December*, 1884.

PREFACE TO FIRST EDITION.

THE *Sailor's Pocket Book* is an attempt to collect in a compact form a series of those small practical facts, a thorough and ready knowledge of which tends to secure the success of the mariner, and the safety of life and property confided to his charge. Some of the notes are taken from the excellent works on seamanship now extant, but the greater number are extracted from the small professional pamphlets, published by, or with the approval of the Admiralty, the Board of Trade, and the Meteorological Office.

These useful little works are liable, from their very form, to be either frequently mislaid or seldom at hand for reference when required; and it was more especially as an endeavour to concentrate the information contained in these pamphlets, that this work was commenced.

In this undertaking I have been much encouraged by the sound practical advice of Captain W. H. Cuming, to whom, in 1869, the idea was first communicated; the interval of half-pay following promotion afforded time to begin in earnest, and helping hands and brains soon introduced new features. The work grew so rapidly, that it threatened to assume the proportions of a nautical cyclopædia rather than a pocket-book; and it became a difficulty to know where to stop, what to omit or condense, and what to enlarge upon.

Fortunately, from the outset the work commended itself to my old friend Staff-Commander Thomas A. Hull, the Superintendent of Admiralty Charts, who at once undertook to assist me in the compilation, wrote portions of Sections IV. and V., and pointed out the vast amount of information that was to be gleaned from the charts and books published by the Hydrographic Office of the Admiralty.

Many thanks are also due to Admiral A. P. Ryder for various important suggestions and contributions, particularly in Sections VII. and VIII.; and to Admiral Sir C. F. A. Shadwell for permission to make extracts from his useful work on chronometers. Sections II. and IV. owe much to Staff-Commander E. H. Hills, whose help has been most willingly rendered; Section V. to Admiral G. A. Bedford, and Staff-Commander V. F. Johnson, Instructor of Surveying at the Royal Naval College; Section VI. to Captain G. C. Wilson, and Mr. George Tuck, Chief Engineer, R.N., Instructor in Steam at the Royal Naval College. The Secretary of the Royal National Lifeboat Institution, courteously furnished me with copies of the instructions issued by the Institution, and also allowed me the use of the blocks for illustrating Section VIII. Lieutenant H. H. Grenfell kindly undertook Section VII., while Section VIII. was revised by, and partly re-written by Staff-Surgeon D. J. Duigan, M.D., of this ship. Mr. W. Weston, Admiralty Chemist, Portsmouth, supplied the articles on Disinfectants.

Mr. R. C. Carrington, of the Hydrographic Office, kindly superintended the production of the last Section during my absence from England, and also furnished the book with its comprehensive Index.

Thanks to the hearty co-operation of my brother officers, the book has thus reached its present form. I trust it may be of service to sailors, as a handy work of reference, especially to those who are not gifted with retentive

memories; and that after passing through the necessary criticism, pruned down where diffuse, and enlarged where too brief, it may at some future time find favour with those who from motives of duty or pleasure take an interest in the art of navigation.

F. G. D. B.

H.M.S. *Agincourt*,
MADEIRA, *November*, 1873.

ERRATA.

Page 16, 8th line from bottom, *insert* "Prawle Point."

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SECTION I.

COLOURS—NAVY—NOT NAVY. SIGNALS—FOR PILOTS—OF DISTRESS—NAVAL—INTERNATIONAL. SIGNAL AND SEMAPHORE STATIONS OF FOREIGN COUNTRIES. STORM SIGNALS AND WEATHER INTELLIGENCE.

COLOURS—NAVY.

ALL Her Majesty's Ships of War in Commission wear a White Ensign, with the Red St. George's Cross, and the Union in the upper canton;* and when not bearing a flag or broad pendant,† a long pendant, having a St. George's Cross on a white field in the upper part next to the mast, with a white Fly.

Distinguishing Flags—not naval.

The Flags authorized by Her Majesty to be displayed afloat are—

(*a*) By General and other Military Officer's commanding stations,—the Union, bearing in the centre, as a distinguishing mark, the Royal Initials, surrounded by a Garland on a Blue Shield, and surmounted by the Crown.

(*b*) By Her Majesty's Diplomatic Servants,—the Union, with the Royal Arms in the centre thereof, on a White Shield, surrounded by a Green Garland.

(*c*) By the Governors or High Commissioners of Her Majesty's Colonies and Possessions abroad, and Officers administering the Government,—the Union with the Arms or Badge of the Colony emblazoned in the centre thereof, on a White Shield, surrounded by a Green Garland.

(*d*) By Consuls-General, Consuls, and Consular Agents,—the Blue Ensign, with the Royal Arms in the centre of the Fly thereof, that is, in the centre of the part between the Union Jack and the end of the Flag.

Colours—not Navy.

Section 105 of the Merchant Shipping Act provides that "If any Colours usually worn by Her Majesty's Ships, or any Colours resembling those of Her

* Yachts belonging to the Royal Yacht Squadron are entitled to wear the white ensign.

† See "Sailor's Handbook" in Appendix for a full description of distinguishing flags of Naval Authorities.

Majesty, or any distinctive National Colours, except the Red Ensign usually worn by Merchant Ships, or except the Union Jack with a White border, or if the Pendant usually carried by Her Majesty's Ships, or any Pendant in anywise resembling such Pendant, are or is hoisted on board any ship or boat belonging to any subject of Her Majesty, *without warrant for so doing from Her Majesty or from the Admiralty*, the Master of such ship or boat, or the owner thereof, if on board the same, and every other person hoisting or joining or assisting in hoisting the same shall for every such offence incur a penalty not exceeding five hundred pounds, and it shall be lawful for any officer on full pay in the Military or Naval Service of Her Majesty, or any *British* Officer of the Customs, or any *British* Consular Officer, to board any such ship or boat, and to take away any such Jack, Colours, or Pendant; and such Jack, Colours, or Pendant shall be forfeited to Her Majesty."

BLUE ENSIGN.

Blue Ensign.—Any Vessel provided and used under the 3rd Section of the Colonial Defence Act, 28 Vict., cap. 14, shall wear the Blue Ensign, with the Seal or Badge of the Colony in the Fly thereof, and a Blue Pendant. All Vessels belonging to, or permanently in the service of the Colonies, but not commissioned as Vessels of War under the Act above referred to, shall wear a similar Blue Ensign, but not the Pendant.

Ships and Vessels employed in the service of any Public Office, shall carry a Blue Ensign, and a small Blue Flag, with a Union described in a canton at the upper corner thereof next to the staff, as a Jack; but in the centre of such Ensign and Jack, there shall be described the Seal or Badge of the office to which they belong.

Hired Transports are to wear the Blue Ensign, with the Yellow Admiralty Anchor in the Fly; and when the Vessel is in charge of a Commissioned Officer of the Royal Navy, she is to carry in addition a Blue Pendant, with the Admiralty Badge at the upper part next to the Mast. Hired Vessels employed in the Surveying Service, when commanded by Officers in Her Majesty's Navy, are to wear the Blue Ensign and Pendant.

British Merchant ships fulfilling the following conditions will be allowed to wear the Blue Ensign of Her Majesty's Fleet.

Conditions.

1. The Officer commanding the Ship must be an Officer of the Royal Naval Reserve.

2. Ten of the crew must be men belonging to the Royal Naval Reserve.

3. Before hoisting the Blue Ensign the Ship must be provided with an Admiralty Warrant.

NOTE I.

Ships failing to fulfil the above conditions, unless such failure is caused by death or other circumstances over which the owners have no control, will no longer be entitled to wear the Blue Ensign.

NOTE II.

Officers commanding Her Majesty's Ships meeting with ships carrying the Blue Ensign will be authorized to go on board such ships, at any convenient opportunity, and see that these conditions are strictly carried out, provided that they are superior in rank to the Officer Royal Naval Reserve.

NOTE III.

Applications for permission to wear the Blue Ensign will be forwarded to the Admiralty from the Lords of Privy Council for Trade, who will issue regulations as to the mode of proceeding.

NOTE IV.

All former instructions respecting the Blue Ensign are hereby cancelled.

Officers of the Naval Reserve who are desirous that the ships commanded by them should wear the Blue Ensign, should apply to the Registrar-General of Shipping and Seamen, or to the Superintendent of a Mercantile Marine Office for a Form of Application (R.V. 40) for an Admiralty Warrant.

RED ENSIGN.

Red Ensign.—All other Ships and Vessels belonging to Her Majesty's subjects, shall wear a Red Ensign, with the Union in the upper canton next to the Staff; and shall use a British Union Jack with a border of White, of one-fifth of the Jack, as a Pilot Flag, in all parts of the world; except such Yachts and other Vessels as may have Warrants from the Admiralty to display other Ensigns, Colours, or Pendants.

Yachts belonging to the following Yacht Clubs are entitled by Admiralty Warrant to fly the Blue Ensign.

Royal Dee.	New Thames.	Royal London.
Royal Harwich.	Royal Cornwall.	Royal Western England, E.
Royal Mersey.	Royal Cinque Ports.	Royal Clyde.
Royal Southern.	Royal Southampton.	Royal Channel Islands.
Royal Welsh.	Royal Highland.	Royal Ulster.
Royal Western Ireland.	Royal Eastern.	Royal Forth.
Boston.	Royal Irish.	Royal Dorset.
Royal Albert.	Royal Northern.	Royal Torquay.
	Royal Thames.	

Signals for Pilots.

The Board of Trade give notice, that on and after the 1st of November, 1873, if a vessel requires the services of a Pilot, the Signals to be used and displayed shall, in accordance with the 19th Section of the Merchant Shipping Act, 1873, be the following, viz.:—

"**In the Daytime.**—The following Signals, numbered 1 and 2, when used or displayed together or separately, shall be deemed to be signals for a Pilot in the daytime, viz.:—

"1. To be hoisted at the fore, the Jack or other National colour usually worn by merchant ships, having round it a white border one-fifth of the breadth of the flag; or

"2. The International Code Pilotage Signal indicated by P.T.

"**At Night.**—The following Signals, numbered 1 and 2, when used or displayed together or separately, shall be deemed to be Signals for a Pilot at night, viz:—

"1. The Pyrotechnic Light, commonly known as a Blue Light, every 15 minutes; or

"2. A bright White Light, flashed or shown at short or frequent intervals, just above the bulwarks, for about a minute at a time."

And "any Master of a vessel who uses or displays, or causes or permits any person under his authority to use or display, any of the said Signals for any other purpose than that of summoning a Pilot, or uses, or causes, or permits any person under his authority to use, any other Signal for a Pilot, shall incur a Penalty not exceeding Twenty Pounds."

Signals of Distress.

The Board of Trade give notice, that on and after the 1st of November, 1873, the following Signals shall, in accordance with the 18th section of the Merchant Shipping Act, 1873, be deemed to be Signals of Distress:—

"**In the Daytime.**—The following Signals, numbered 1, 2, and 3, when used or displayed together or separately, shall be deemed to be Signals of Distress in the Daytime:—

"1. A gun fired at intervals of about a minute.

"2. The International Code Signal of Distress indicated by N. C.

"3. The Distant Signal, consisting of a square flag, having either above or below it a ball, or anything resembling a ball.

"**At Night.**—The following Signals, numbered 1, 2, and 3, when used or displayed together or separately, shall be deemed to be Signals of Distress at Night:—

"1. A gun fired at intervals of about a minute.

"2. Flames on the ship (as from a burning tar barrel, oil barrel, etc).

"3. Rockets or shells of any colour or description, fired one at a time, at short intervals."

And "any Master of a vessel who uses or displays, or causes or permits any person under his authority to use or display any of the said signals, except in the case of a vessel being in distress, shall be liable to pay compensation for any labour undertaken, risk incurred, or loss sustained, in consequence of such signal having been supposed to be a signal of distress; and such compensation may without prejudice to any other remedy, be recovered in the same manner in which salvage is recoverable."

Naval Compass Signals.

COMPASS PENDANT OVER.

No.	Letters.	Points.	No.	Letters.	Points.
42	A B	NORTH.	18	B P	EAST.
421	A C	N. ¼ E.	181	B Q	E. ¼ S.
422	A D	N. ½ E.	182	B R	E. ½ S.
423	A E	N. ¾ E.	183	B S	E. ¾ S.
11	A F	N. by E.	19	B T	E. by S.
111	A G	N. by E. ¼ E.	191	B W	E. by S. ¼ S.
112	A H	N. by E. ½ E.	192	B Y	E. by S. ½ S.
113	A I	N. by E. ¾ E.	193	C D	E. by S. ¾ S.
12	A K	N. N. E.	20	C E	E. S. E.
121	A L	N. N. E. ¼ E.	201	C F	S. E. by E. ¾ E.
122	A M	N. N. E. ½ E.	202	C G	S. E. by E. ½ E.
123	A N	N. N. E. ¾ E.	203	C H	S. E. by E. ¼ E.
13	A O	N. E. by N.	21	C I	S. E. by E.
131	A P	N. E. ¾ N.	211	C K	S. E. ¾ E.
132	A Q	N. E. ½ N.	212	C L	S. E. ½ E.
133	A R	N. E. ¼ N.	213	C M	S. E. ¼ E.
14	A S	N. E.	22	C N	S. E.
141	A T	N. E. ¼ E.	221	C O	S. E. ¼ S.
142	A W	N. E. ½ E.	222	C P	S. E. ½ S.
143	A Y	N. E. ¾ E.	223	C Q	S. E. ¾ S.
15	B C	N. E. by E.	23	C R	S. E. by S.
151	B D	N. E. by E. ¼ E.	231	C S	S. S. E. ¾ E.
152	B E	N. E. by E. ½ E.	232	C T	S. S. E. ½ E.
153	B F	N. E. by E. ¾ E.	233	C W	S. S. E. ¼ E.
16	B G	E. N. E.	24	C Y	S. S. E.
161	B H	E. by N. ¾ N.	241	D E	S. by E. ¾ E.
162	B I	E. by N. ½ N.	242	D F	S. by E. ½ E.
163	B K	E. by N. ¼ N.	243	D G	S. by E. ¼ E.
17	B L	E. by N.	25	D H	S. by E.
171	B M	E. ¾ N.	251	D I	S. ¾ E.
172	B N	E. ½ N.	252	D K	S. ½ E.
173	B O	E. ¼ N.	253	D L	S. ¼ E.

The Letters are used with Flags, and numbers with distant or Flashing Signals.

COMPASS SIGNALS.—*(Continued.)*

COMPASS PENDANT OVER.

No.	Letters.	Points.	No.	Letters.	Points.
26	D M	SOUTH.	34	F N	WEST.
261	D N	S. ¼ W.	341	F O	W. ¼ N.
262	D O	S. ½ W.	342	F P	W. ½ N.
263	D P	S. ¾ W.	343	F Q	W. ¾ N.
27	D Q	S. by W.	35	F R	W. by N.
271	D R	S. by W. ¼ W.	351	F S	W. by N. ¼ N.
272	D S	S. by W. ½ W.	352	F T	W. by N. ½ N.
273	D T	S. by W. ¾ W.	353	F W	W. by N. ¾ N.
28	D W	S. S. W.	36	F Y	W. N. W.
281	D Y	S. S. W. ¼ W.	361	G H	N. W. by W. ¾ W.
282	E F	S. S. W. ½ W.	362	G I	N. W. by W. ½ W.
283	E G	S. S. W. ¾ W.	363	G K	N. W. by W. ¼ W.
29	E H	S. W. by S.	37	G L	N. W. by W.
291	E I	S. W. ¾ S.	371	G M	N. W. ¾ W.
292	E K	S. W. ½ S.	372	G N	N. W. ½ W.
293	E L	S. W. ¼ S.	373	G O	N. W. ¼ W.
30	E M	S. W.	38	G P	N. W.
301	E N	S. W. ¼ W.	381	G Q	N. W. ¼ N.
302	E O	S. W. ½ W.	382	G R	N. W. ½ N.
303	E P	S. W. ¾ W.	383	G S	N. W. ¾ W.
31	E Q	S. W. by W.	39	G T	N. W. by N.
311	E R	S. W. by W. ¼ W.	391	G W	N. N. W. ¾ W.
312	E S	S. W. by W. ½ W.	392	G Y	N. N. W. ½ W.
313	E T	S. W. by W. ¾ W.	393	H I	N. N. W. ¼ W.
32	E W	W. S. W.	40	H K	N. N. W.
321	E Y	W. by S. ¾ S.	401	H L	N. by W. ¾ W.
322	F G	W. by S. ½ S.	402	H M	N. by W. ½ W.
323	F H	W. by S. ¼ S.	403	H N	N. by W. ¼ W.
33	F I	W. by S.	41	H O	N. by W.
331	F K	W. ¾ S.	411	H P	N. ¾ W.
332	F L	W. ½ S.	412	H Q	N. ½ W.
333	F M	W. ¼ S.	413	H R	N ¼ W.

The Letters are used with Flags, and numbers with distant or Flashing Signals.

FLASHING SIGNALS.

FLASHING Signals are made by the motion of any single object. In most instances the object is made to appear and disappear; and in others it is made to change its position, so that one position shall represent the appearance and the other the disappearance of the object. The symbols are determined by successive appearances and disappearances at regulated intervals, constantly recurring after a fixed pause.

The appearances of the object are termed FLASHES, and are of two lengths, termed "short" and "long" flashes, which are used in combination, to express the signs required, and are usually written thus: — to express the SHORT flash; ——— to express the LONG flash; the interval of obscuration, or of the disappearance of the object, being left blank.

The *long* flash should be at least three times as long as the *short* one.

The disappearances of the object are termed INTERVALS, and are of three lengths. That between the flashes composing a figure is equal in duration to a *short* flash; that between two figures is equal to a *long* flash; and that between any two repetitions of a signal is equal to one-third of the whole length of the signals, or from about seven to ten seconds.

At *night* those signals are made by the obscuration and exposure of a single light; in the *daytime*, by the different apparatus which may be employed.

At short distances no special apparatus is necessary, the simple waving of the arm with a hat, flag, handkerchief, etc., being sufficient.

The system is equally applicable in fogs; long and short sounds on a fog horn, bugle, or steam whistle, representing the *long* and *short* flashes.

In all cases the signals or combinations have the same signification, so that an observer, having learnt the use of one apparatus, can read and make signals with any other description of apparatus without further instruction.

The following Tables exhibit the Signs necessary for use with this Code:—

Numerals.

1 —	6 ———
2 — —	7 — ———
3 — — —	8 ——— —
4 — — — —	9 — — ———
5 — — — — —	0 ——— — —

Auxiliary Signs.

Compass — – —
Pendants — – – —
Numeral — – – – –
Special and Repeat } – — – –
Horary – – — –
Interrogative – – – —
Negative — – – –
List of Navy – — –
Groups – – — – –

Answer — – — – — – a continuation of *long* and *short* flashes.

Morse Spelling – — — –

Preparative — – – – – – a continuance of *short* flashes.

Stop — — — a continuance of *long* flashes.

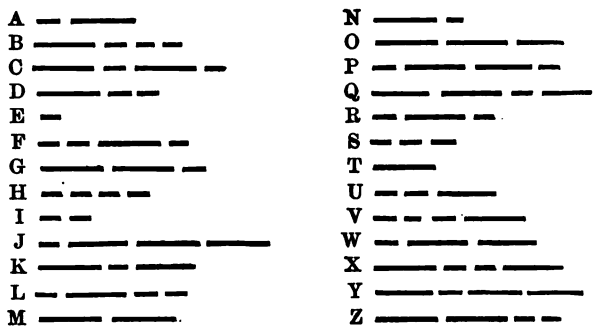
THE MORSE ALPHABET.

THE system has but two simple elements, called a dot and a dash, and these are combined in groups to make up the signals necessary to form an alphabet.

The dot is taken as a unit, and the dash represents three times the length of the dot. The interval between the elements forming a letter is equal to one unit. The pause between each complete sign, or letter, should be made equal to a dash, or three units.

At night these signals are in all cases made by the obscuration and exposure of a single light; in the daytime different apparatus may be used under the varying circumstances of service.

On the spelling sign being made the ship or ships addressed will show a steady light, obscuring it when the sense of the sentence is missed, in exactly the same manner as the semaphore answering pendant is dipped in the daytime.



Signs used in connection with the Alphabet:—

Comma (,) — — — — — — (A A A)

Full stop (.) — — — — — — (I I I)

Preparative — — — — — — — — — — — — a continued succession of dots.

Stop — — — — — — — — — — — — a continued succession of dashes.

General answer - - - - - - - - - - - a steady light.

Repeat — — — — —

Numeral — — — — — —

Morse or Spelling Sign — — — — —

Negative — — — — —

FLASHING SIGNALS WITH FLAGS.

FROM the fact that flags are not fully exposed to view unless kept in motion, and as the plan of exposure and concealment cannot be employed in using them, a different arrangement is adopted to make flashing signals.

The signalman may work from left to right, or from right to left, as shown in Figs. 1 and 2, according to convenience, and the direction of the wind. To make a *short* flash—the flag is waved from *a* to *b*, back to the normal position *a*. To make a *long* flash—the flag is waved from *a* to *c*, and after a distinct pause, brought back to the normal position, *a*.

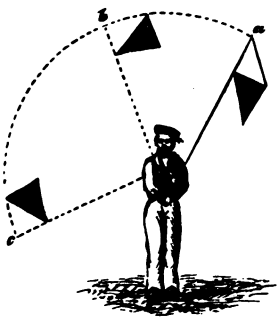


Fig. 1.

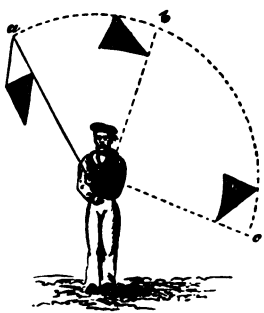


Fig. 2.

The numerals 1 to 5 are, therefore, denoted by one to five waves of the flag from *a* to *b* recovering to *a*. The numeral 6, by a wave from *a* to *c*, recovering to *a*. The numeral 7, by a wave from *a* to *b*, back to *a*, and then to *c*, recovering to the normal position, *a*. The numeral 8 is denoted by a wave from *a* to *c*, back to *a*, and then to *b*, recovering to the normal position, *a*. The numeral 9 is denoted by two waves from *a* to *b*, and one from *a* to *c*. The numeral 0, by one wave from *a* to *c*, recovering again to *a*, and then two waves from *a* to *b*. The other signs are made in the same manner, so that a short motion shall always represent a *short* flash, and a long motion a *long* flash.

On the completion of the motions required for each sign, the flag must always be brought to the position *a*. When the word, or group of figures is completed, the butt of the staff may be brought to the ground, and the flag at the same moment gathered in. In waving the flag, the point of the staff should be made to describe a figure of 8 in the air, to keep the flag clear. In all other respects flashing signals are carried on in precisely the same manner with flags as with any other instruments.

Horary Table.

11	...	...	1 P.M.	23	...	...	1 A.M.
12	...	...	2 ,,	24	...	...	2 ,,
13	...	...	3 ,,	25	...	...	3 ,,
14	...	...	4 ,,	26	...	...	4 ,,
15	...	...	5 ,,	27	...	...	5 ,,
16	...	...	6 ,,	28	...	...	6 ,,
17	...	...	7 ,,	29	...	...	7 ,,
18	...	...	8 ,,	30	...	...	8 ,,
19	...	...	9 ,,	31	...	...	9 ,,
20	...	...	10 ,,	32	...	...	10 ,,
21	...	...	11 ,,	33	...	...	11 ,,
22	...	...	12 midnight.	34	...	...	12 Noon.

Minutes are denoted by their proper figures. Thus:—hor. 2135 = 35 minutes past 11 p.m. Seconds must be made separately.

The *Compass Sign* is used with numerals as given in the Compass Table.

Pendants.—This sign is used with the numerals to represent Distinguishing Signals, thus: Single ships are distinguished by the number of their Pendants given in the Pendant board, with this Sign.

Divisions, etc., are distinguished as follows:—

Pendants sign	1	signifies	1st	Division.	Pendants sign	01	denotes	1st Sub-division
,,	,, 2	,,	2nd	,,	,,	,, 02	,,	2nd
,,	,, 3	,,	3rd	,,	,,	,, 03	,,	3rd
,,	,, 4	,,	4th	,,	,,	,, 04	,,	4th
,,	,, 5	,,	5th *	,,	,,	,, 05	,,	5th
,,	,, 6	,,	6th †	,,	,,	,, 06	,,	6th
,,	,, 7	,,	Transports		,,	,, 07	,,	7th
,,	,, 8	,,	Torpedo vessels		,,	,, 08	,,	8th
,,	,, 9	,,	Colliers		,,	,, 09	,,	9th
,,	,, 0	,,	Gunboats		,,	,, 00	,,	10th
					,,	,, 11	,,	11th
					,,	,, 22	,,	12th

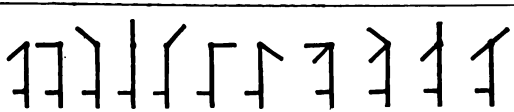
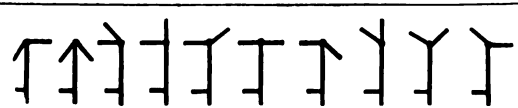
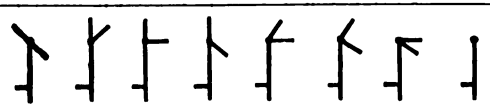
or Group with Group Sign.

Pendant sign 33 denotes Ships on the Starboard side of the Admiral.
,, ,, 44 ,, Ships on the Port side of the Admiral.
,, ,, 55 ,, Convoy.

The *Numeral Sign* is expressive of number only.

* Or detached squadron. † Or corvettes, sloops, etc.

SEMAPHORE SIGNS.

Numerical Application.	1	2	3	4	5	6	7	8	9	0	15
											
Application to Vocabulary.	A	B	C	D	E	F	G	H	I&J	K	L
Numerical Application.	16	17	23	24	25	26	27	34	35	36	
											
Application to Vocabulary.	M	N	O	P	Q&X	R	S&Z	T	UV&W	Y	
Numerical Application.	37	45	46	47	56	57	67	Indicator			
											
Governing Signs.	Annul	Numeral	Alpha-bet	Special	Vocab. Sig. Book.	Ship's Name	Gen. Sig. Bk.	Preparative, and when taken in denotes finish.			

THE INTERNATIONAL CODE OF SIGNALS.

THIS Code has been adopted by the following Maritime Powers, viz:—

Great Britain.	Denmark.	Russia.	Austria.	Portugal.
France.	Holland.	Greece.	Germany.	Brazil.
America.	Sweden.	Italy.	Spain.	Belgium.

SIGNAL STATIONS.

SIGNAL Stations on the Coasts of the United Kingdom.

The proprietors of the "Shipping and Mercantile Gazette" have established Signal Stations with which Ships can communicate by means of the International Code at:—

Aldborough.
Bridlington Quay
Flamborough Head.
Great Yarmouth.
Grimsby.
Margate.
Old Head of Kinsale (Ireland).
Portland Bill.
Prawle Point.
Yarmouth (Isle of Wight).

The Committee of Lloyd's have also established, or are in course of establishing, Signal Stations on the following points of the Coast, viz. :—

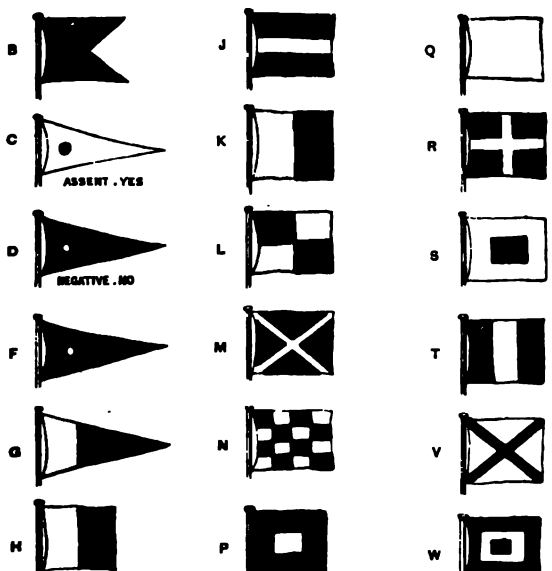
Southend.
North Foreland.
Deal.
Dover.
Dungeness.
Beachy Head.
St. Catherine's Point (Isle of Wight).
Hurst Castle.
The Lizard.
Scilly Islands.
St. Ann's Head (Milford Haven).
Lundy Island.
Spurn Point.
Cromer.
Brow Head (Crookhaven, Ireland).
The Fastnet Rock (Ireland).
Galley Head (Ireland).
Roche's Point (Queenstown, Ireland).
Malin Head (Co. Donegal, Ireland).
Rathlin Island (Co. Antrim, Ireland).
Kildonan (Mouth of the Clyde, Scotland).
Dunnet Head, N.B.
Peterhead, N.B.
Aberdeen, N.B.

These Stations are to be available to Shipowners for reporting to them the passing of their vessels, by telegrams despatched direct from the Signal Stations.

FLAGS OF THE INTERNATIONAL CODE OF SIGNALS.

"CODE SIGNAL" AND "ANSWERING PENDANT."

When used as the "Code Signal," this Pendant is to be hoisted under the "Ensign." For "Answering Pendant," where best seen.



The following examples will serve to illustrate how the form of a Hoist will usually denote the nature of the Signal made.

Two Flags.

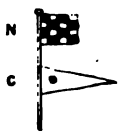
BURGEE uppermost, "ATTENTION" Signals.

WHAT SHIP IS THAT?

PENDANT uppermost, "COMPASS" Signals.

W. BY S.

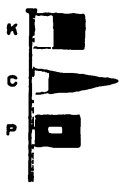
SQUARE FLAG uppermost, "URGENT." Signals.



IN DISTRESS, WANT ASSISTANCE.

Three Flags.

GENERAL SIGNALS.



ENGINE BROKEN DOWN.

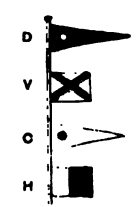
CALL FOR ORDERS OFF.

Four Flags.

BURGEE uppermost, GEOGRAPHICAL Signals.

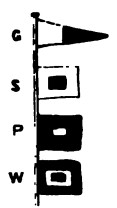
FALMOUTH.

PENDANTS C, D, F, uppermost, VOCABULARY.



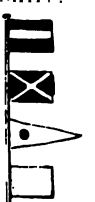
WHAT SHIPS HAVE YOU SPOKEN?

PENDANT G uppermost, Names of MEN-OF-WAR.



"MONARCH" TURRET SHIP, 7 GUNS.

SQUARE FLAG uppermost, Names of MERCHANT SHIPS.



"MARCO POLO" No. 6025.

The majority of these Stations are now fully organized for reporting to Shipowners, and the remainder will be in operation as soon as the construction of the telegraph wires connecting the stations with the postal telegraph system of the country is completed.

All applications from Shipowners for their Vessels to be reported to them should be addressed to the Secretary of Lloyd's, London, E.C.

There are also Signal stations with which Shipowners can communicate by means of the *International Code* at

Aden.	Malta.	Skagen (Denmark).
Anjer (Straits of Sunda).	Madeira.	St. Helena.
Ascension.	Oitavos (Portugal).	Torres Straits.
Cape Carvoeiro (Portugal).	Oxo (Norway).	Ushant.
Cape Point (Cape Good Hope).	Palais (Belle Ile).	
Gibraltar.	Sagres, C. St. Vincent (Portugal).	

At these Signal Stations the International Code is the *only* Code recognized, and Vessels of any nation may make their names known by means of this Code, and thus secure the immediate publication of the announcement in "Lloyd's List," "Lloyd's Weekly Shipping Index," and the "Shipping and Mercantile Gazette." Cases of wreck or other accidents at sea should always be made known by Shipmasters to the Signal Stations with which they communicate.

Government Signal Stations have also been established on the coasts of France and Italy, and other foreign countries. See pp. 26–29.

Reports by Her Majesty's Ships.

The Lords Commissioner of the Admiralty, with a view of benefiting the Mercantile Marine interests of this country, have directed Commanding Officers of Her Majesty's Ships, to make a return of each Merchant Vessel signalled or spoken at sea *by the International Code of Signals*, and to forward the reports to England as opportunities offer. These reports will be published in "Lloyd's List," and the "Shipping Gazette."

Masters of Ships who wish to be reported are requested to observe the following rules in signalling, when sighting Ships or Signal Stations:—

Show your Colours, with Code Flag under.

1st Signal.—Hoist the Four Flags which denote your Distinguishing Signal in the Code List.

2nd Signal.—Hoist the Four Flags which denote the Port you are bound from.

3rd Signal.—Hoist the Four Flags which denote the Port you are bound to.

4th Signal.—If you think it necessary, number of days out, from Numeral Table, p. 73 of Part I., International Code.

General Instructions for Using the Code.

Hoist the Signal where it will be best seen. The proper Signal to hoist may be easily found by reference to Part II., International Code.

In Part I. the principal Signals bearing upon the same subject are arranged in groups.

A separate Geographical Index will be found at the end of Part II.

The meaning of any Signal will be found opposite to the letters represented by the Flags shown. By the arrangement of the Flags and Pennants as shown in the plate of Flags, it will be observed from the examples that a *distinctive character* is given to the Signals; thus,

Two-flag Signals having the *Burgee uppermost*, are "Attention" Signals.

" " " *Pennant uppermost*, are "Compass" Signals.

" " " *Square flag uppermost* are "Urgent" Signals.

Three-flag Signals are Universal, and express Latitude, Longitude, Time, Numeral, and all ordinary Signals required for communications.

Four-flag Signals having the *Burgee uppermost* are "Geographical" Signals.

" " " *Pennant uppermost* are "Spelling" and "Vocabulary" Signals and Names of Men of War.

" " " *Square flag uppermost* are Names of Merchant Vessels.

COMPASS SIGNALS.

C B	North.	D B	East.	F B	South.	G B	West.
C F	N. by E.	D F	E. by S.	F D	S. by W.	G D	W. by N.
C H	N. N. E.	D H	E. S. E.	F H	S. S. W.	G H	W. N. W.
C K	N.E. by N.	D K	S.E. by E.	F K	S.W. by S.	G K	N.W. by W.
C M	N. E.	D M	S. E.	F M	S. W.	G M	N. W.
C P	N.E. by E.	D P	S.E. by S.	F P	S. W. by W.	G P	N.W. by N.
C R	E. N. E.	D R	S. S. E.	F R	W. S. W.	G R	N. N. W.
C T	E. by N.	D T	S. by E.	F T	W. by S.	G T	N. by W.

Extracts of Danger or Distress Signals from Signal Book.

(*Those considered as most urgent.*)

Assistance.

H B. Want immediate assistance.
H D. No assistance can be rendered.
H F. We are coming to your assistance.

Boats.

H J. Boat, or life-boat cannot come.
H K. Boat in distress.
H L. Do not attempt to land in your own boats.
H M. Man overboard.

Communicate.

H P. Close; I have important intelligence.
H Q. Allow no person on board.

Damage or Accident.

H V. Damaged rudder; cannot steer.
H W. Machinery disabled.
J B. Accident; want a surgeon.

Danger or Caution.

J D. You are standing into danger.
J F. You are in a dangerous position.
J P. Heavy weather coming; look sharp.

Directions for a Vessel under Weigh.

J S. Stand off; get an offing.
J W. Heave to; stop her instantly.
K B. Heave all aback; go astern.
K D. Stand on.
K J. Get her on the other tack, or you will be on shore.
K N. Keep to windward.
K F. Bar impassable.
K Q. Channel has altered; do not try it.
K R. Dangerous without a pilot.
K S. Buoys, or marks, are not in their proper position.
K T. Port the helm (*to be flown until course is sufficiently altered*).
K V. Starboard the helm (Ditto).
L C. Steady the helm.
L D. Steer after me.
L F. Keep on the port shore, or side of channel.
L G. Keep on starboard shore, or side of channel.
L H. Keep in centre of channel.
L M. The berth you are now in is not safe.
L N. Run on the beach. Beach the vessel.
L P. Anchor instantly.

Directions to a Vessel at Anchor.

L R. Weigh, cut, or slip; wait for nothing.
L S. Put to sea at once; get an offing.
L V. Shift your berth; your berth is unsafe.
M C. Should you part, beach where people are assembled, or by comp signal from you as will be pointed out.
M F. Hold on until high water.

Directions for Saving Crew.

M K. Remain by the ship.
M L. Quit the vessel as fast as possible.
M P. Landing is impossible.

M Q. Look out for a line.
M R. Endeavour to send a line.
M S. Do the best you can for yourselves; no assistance can be given.
M V. Lights or fires will be kept at the best places for coming on shore.
M W. Keep a light burning.

Distress.

N C. In distress; want assistance.
N D. I must abandon the vessel.
N F. Do not abandon me.
N G. I am unmanageable.
N H. I am in danger, or shoal water; direct me how to steer.

Fire.

N M. I am on fire.
N P. Fire gains rapidly; take people off.
N Q. With immediate assistance, fire can be extinguished.

Leak.

N S. I have sprung a leak.
N T. Leak is gaining rapidly.
N V. I am sinking.

Wants.

P C. Want assistance; mutiny.
P D. Want immediate medical assistance.
P F. Want boat, or boats, immediately.
P H. Want food; starving.
P J. Want coal immediately.
P K. Want an anchor.
P N. Want a steam-tug.
P S. Want hands.
P T. Want a pilot; can one be obtained? (*Answer* "Yes" or "No").
Q C. Repeat signal.
Q H. Stop, or heave to; I have something to communicate.

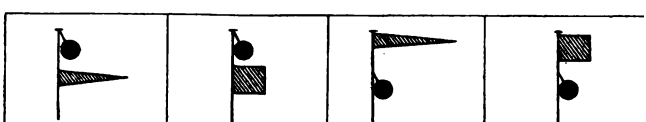
DISTANT SIGNALS.

THE *characteristic* of the Distant Signal is the *Ball*—one Ball at least pearing in every hoist of the Distant Code. With respect to the two o Symbols, they may be Pennants or Square Flags of any colour.

SIGNIFICATIONS of the DISTANT SIGNALS when made *singly*, which wil indicated by the "*stop*" following each hoist.

B. Asks name of ship or Signal Station in sight.
C. Yes.
D. No.
F. Repeat Signal, or hoist it in a more conspicuous place.
G. Cannot distinguish your Flags. Come nearer, or make Distance Signals.
H. You may communicate by the Semaphore, if you please.
J. Stop, or bring to. Something important to communicate.
K. Have you any telegrams or dispatches for me?
L. Want a pilot. Can I have one?
M. Want a tug. Can I have or
N. What is the Meteorolog Weather Forecast?
P. Calls attention of Signal Sta in sight.
Q. Vessel asks for orders by graph from owner, Mr. – at ——.
R. Report me by telegraph to owner, Mr. ——, at ——.
S. Send the following messag telegraph.
T. Send the following message the *Signal Letters*, thro the telegraph.

In addition to the above, the following Distance Signals, composed of *Symbols*, have the special signification indicated beneath.



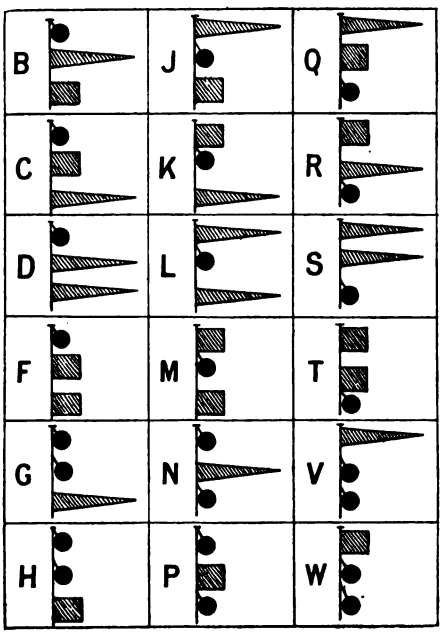
You are running into danger.	Fire; or Leak. Want immediate assistance.	Short of Provisions. Starving.	Aground. Want immediate Assistance.

GENERAL ALPHABETICAL TABLE for Composing Distance Signals.

Preparative Answering

and also
Stop after each complete Signal.

Annul Signal.



Boat Signals.

The Symbols for Boat Signals are:—

1. Two *square* flags, or handkerchiefs, or pieces of cloth.

2. Two long strips of cloth, or parts of a plank, or pieces of wood longer than broad—(for pennants).

3. Two balls, or hats, or round bundles, or buckets.

With these any of the Signals of the *Distant Signal Code* can be made—holding the Symbol at arm's length; and the Signal is to be *made from right to left* and *read from left to right*, thus:—

Equivalent to Ball above Pennant, or "You are Running into Danger."

Signifying "Accident; want a Surgeon."

"Stop;" or Finish after each complete signal.

Semaphore Signals.

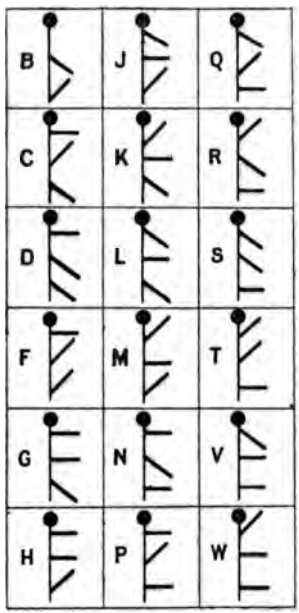
Semaphore masts are furnished with *Three Arms*, which are used as follows in the representation of any of the Distance Signals:—

1. The *Disc* at the *top of the mast* indicates that Signals are being made by the *International Code*, and it must remain there whilst so signalling. It is a large *black disc with white rim.*

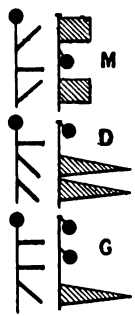
2. Any *arm* pointing *downward* represents a PENNANT.

3. Any *arm* in a *horizontal* position represents a BALL.

4. Any *arm* pointing *upward* represents a FLAG.



Examples



M D G

"Leave the Buoy or Beacon to port."

When the arms are not working they are not visible, but lie parallel with the masts.

Electro-Telegraphic Semaphore and Signal Stations on the Coasts of Foreign Countries.

The Semaphores, or Signal Stations, established on the coasts of France and other countries, have means of intercommunication by electro-telegraphic wires with the chief Metropolitan, Provincial, and Foreign Telegraph Stations.

By the method before described (pp. 17 to 25) passing vessels are able to exchange communication with these Semaphores, and their messages are received, and if required forwarded to their destination, according to the established tariff of rates.

Communications between Ships and the Semaphores are made *exclusively by the Signals of the International Code.*

At a moderate distance the Signal Flags of the Code can of course be used by both Ships and Signal Stations, but the *Distant Signals* should on all occasions be employed by Ships when it is found that the Code Flags cannot be made out.

The Semaphore Signals are *always read off as Distant Signals*, the position or direction of the arms indicating respectively the *Pennant*, the *Ball*, or the *Flags* (see Plate, p. 25).

List of Stations.

France.

FIRST DIVISION.—OCEAN.

1 Zuydcoot.
2 Dunkerque.
3 Gravelines.
4 Calais.
5 Cape Gris-nez.
6 D'Alpreck, Pt.
7 Du Touquet, Pt.
8 Cayeux (St. Valéry-sur-Somme).
9 Tréport.
10 Dieppe.
11 D'Ailly, Pt.
12 St. Valery-en-Caux.
13 Fécamp.
14 Etretat.
15 Cape d'Antifar.
16 Cape de la Hève.
17 Beuzeval, Pt.
18 Ouistreham.
19 St. Aubin.
20 Port-en-Bessin.
21 De la Percée, Pt.
22 Isle St. Marcouf.
23 La Hougue.
24 Barfleur.
25 Cape Lévi.
26 Isle Pelée.
27 Fort of Querqueville.
28 Jardeheu, Pt.
29 Cape La Hague.
30 Nez de Jobourg.
31 Flamanville.
32 Carteret.
33 Port Bail.
34 D'Agon Pt.
35 Du Roc Pt.
36 Isle Chausey.
37 Du Grouin Pt.
38 Besnard Pt.
39 St. Servan.
40 Du Décollé, Pt.
41 St. Cast Pt.
42 Cape Fréhel.
43 Cape d'Erquy.
44 Roselier Pt.
45 St. Quay Pt.
46 Plouezec, Pt.
47 Bréhat, Id.
48 Creac'h-ar-Maout.
49 Port Blanc.
50 Ploumanach, Pt.

France—(*continued*).

51 Bihit, Pt.
52 Primel, Pt.
53 Bloscon, Pt.
54 Isle de Batz.
55 Kerisoc, Pt.
56 L'Alberwrac'h.
57 Landunèves, Pt.
58 Corsen, Pt.
59 Ouessant, Lighthouse.
60 Ouessant, Pt.
61 Le Conquet.
62 St. Mathieu, Pt.
63 Créac'hmeur, Pt.
64 Minou, Pt.
65 Portzic, Pt.
66 Camaret.
67 Des Pois, Pt.
68 Cape la Chèvre.
69 Rosmeur, Pt. (Donarnenez).
70 Bec du Raz-de-Sein.
71 L'Ervely, Pt. (Audierne).
72 Penmarc'h.
73 Lescounil, Pt.
74 Combrit.
75 Beg-Meil.
76 Trevignon, Pt.
77 Isle Penfret (Iles Glenan).
78 L'Anse du Pouldu.
79 Pointe de Bec, Melen. } Isle de
80 Point de la Croix. } Groix.
81 Point de Gâvres (Port Louis).
82 Point Taillefer. }
83 Point d'Arzic. } Belle
84 Point du Talus. } Isle.
85 Point Er-Hastellic. }
86 Loemaria (Quiberon).
87 D'Hoëdic, I.
88 Piriac, Pt.
89 Chemoulin, Pt.
90 St. Gildas, Pt.
91 De Pilier, I.
92 D'Yeu, I.
93 Sables d'Olonne.
94 Des Baleines, Pt. (Isle de Re').
95 De Chassiron, Pt. (Isle d'Oléron).
96 D'Aix, I.
97 Ee la Coubre, Pt.
98 De Grave, Pt.
99 Cape d'Arcachon.
100 Cape Breton.
101 Biarritz.
102 Soccoa (St. Jean de Luz).

SECOND DIVISION.—MEDITERRANEAN.

1 Cape Béarn.
2 Cape Leucate.
3 Cape d'Agde.
4 Cape de Cette.
5 Saintes Maries, Pt.
6 Faraman.
7 Bouc.
8 Pomègues, I.
9 Cape Croisette.
10 Bec de l'Aigle (La Ciotat).
11 Six-fours.
12 Cape Sicié.
13 Cape Sépet.
14 Giens.
15 De Porquerolles, I.
16 Cape Bénat.
17 Du Levant, I.
18 Cape Camarat.
19 Des Sardinaux, Pt.
20 Cape Drammont.
21 St. Marguerite, I.
22 Cape la Garoupe (Antibes).
23 Cape Ferret (Ville franche).
24 Cape San Martino.
25 Cape Corse. }
26 Mortella, Pt. }
27 Rousse, I. }
28 Cape Cavallo. }
29 Sanguinaire, I. } Corsica.
30 Cape Pertusato (Bonifacio). }
31 Porto Vecchio. }
32 Cape Sagro. }

Portugal.

1 Vianna (Mouth of Lima).
2 Luz (Mouth of Douro).
3 Cape Carvoeiro (Peniche).
4 Oitavos (Point da Guia).
5 Cascaes.
6 St. Julião (Mouth of Tejo).
7 Cape Espichel.
8 Cape St. Vincent (Sagres).
9 Point Pargo.
10 Point St. Lourenzo.
11 Ithén (Rock near Harbour of Funchal, Madeira Island).
12 Cape Sines.

Italy.

1 Bari.
2 Brindisi.
3 Capo d'Armi.
4 Capo Spartivento (Calabria).
5 Cappuccini di Ancona.
6 Capri (isola).

Italy—(*continued*).

7 Cozza Spadaro (Capo Passaro).
8 Favignana (isola).
9 Forio d'Ischia.
10 Forte Spuria (Stretto Messina).
11 Massa Lubrense.
12 Taormina.
13 Monte Pellegrino.
14 Monte Saraceno.
15 Monte Conero.
16 Punta Palascia.
17 Palmaria (isola).
18 Po di Primaro.
19 Piombina.
20 Ponza (isola).
21 Portofino.
22 Porida (isola).
23 St. Benigno.
24 Santa Maria di Leuca.
25 St. Teodora (Trapani).
26 Torre Chiaruccia.
27 Torre dei Piloti Alberoni.
28 Torre Miletto.
29 Tremiti.
30 Ventotene.
31 Viesti.

In Project.

1 Asinara (Sardegna).
2 Capo di Noli (Liguria).
3 Capo Teulada (Sardegna).
4 Capo Palinuro (Calabria).
5 Capo Colonna (Calabria).
6 Capo di Mele (Liguria).
7 Capo Vaticano (Calabria).
8 Capo Santa Croce (Sicilia).
9 Cavoli (Sardegna).
10 Elba (Toscana).
11 Lanterna di Piave (Veneto).
12 Licata (Sicilia).
13 Livorna (Toscana).
14 Maddalena (Sardegna).
15 Monte Argentaro (Toscana).
16 Monte Circello (Province Romana).
17 Porto Empedocle (Sicilia).
18 Punta del Mesco (Liguria).
19 Punta Santa Croce (Liguria).
20 San Pietro (Sardegna).
21 San Vito Chietino (Abruz. Cit.).
22 San Vito del Jonio (Terra d'Otranto).
23 Pianosa (Toscana).
24 Razzoli (Isola Sardegna).

Germany.

WANGEROOG ISLAND.—West of the entrance to the river Weser.

Note.—This Signal Station is at the Lighthouse on the Island, and is in connection with the Continental Telegraphs.

Austria.

ISLAND OF LISSA.

Note.—This Signal Station is not far distant from the Lighthouse, and is connected with the Continental Telegraphs.

Denmark.

A Signal Station in connection with the Telegraph Station has been opened at HIRTSHALS or N.W. coast of Jutland.

Norway.

A Signal Station has been opened at Oxo.

Spain.

SANTANDAR.—A Semaphore has been erected, and is worked in accordance with the International Code.

United States of America.

THE ATLANTIC COAST.

1 Atlantic City, N.J.
2 Baltimore, Md.
3 Barnegat, N.J.
4 Booth Bay, Me.
5 Boston, Mass.
6 Cape Hatteras, N.C.
7 Cape Henry, Va.
8 Cape Look-out, N.C.
9 Cape May, N.J.
10 Charleston, S.C.
11 Chatham, Mass.
12 City Island, N.Y.
13 Deer Island, Me.
14 Fort Macon, N.C.
15 Gloucester, Mass.
16 Highland Light, Mass.
17 Hyannis, Mass.
18 Jacksonville, Fla.
19 Key West, Fla.
20 Kittyhawk, N.C.
21 Lewes, Del.
22 Marblehead, Mass.
23 New Bedford, Mass.
24 Newburyport, Mass.
25 New Haven, Conn.
26 New London, Conn.
27 Newport, R.I.
28 New York City.
29 Norfolk, Va.
30 Portland, Me.
31 Portsmouth, N.H.
32 Rockland, Me.
33 Sandy Hook, N.J.
34 Savannah, Ga.
35 Smithville, N.C.
36 Stonington, Conn.
37 Thatcher's Is., Mass.
38 Tybee Island, Ga.
39 Wilmington, N.C.
40 Wood's Hole, Mass.

THE GULF COAST.

1 Galveston, Texas.
2 Indianola, Texas.
3 Mobile, Ala.
4 New Orleans, La.
5 Pensacola, La.
6 Port Eads, La.
7 St. Marks, Fla.

STORM SIGNALS AND TELEGRAPHIC WEATHER INTELLIGENCE.

THE Meteorological Office issues (free of charge) to ports and fishing stations approved of by the Board of Trade, notices of atmospherical disturbances on or near the coasts of the British Islands.

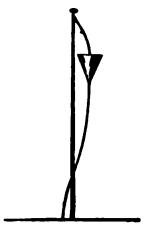
Signals.—The fact that such a notice has been received at any station is made known by a Signal, which is hoisted on the receipt of the message, and remains hoisted (but only during the daytime) for the space of 48 hours and no longer, counted from the time the message is sent out.

The Signals are made by means of a Cone.

The Cone is three feet high and three feet wide at base, and appears as a triangle when hoisted.

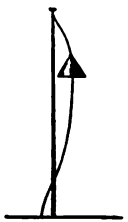
CAUTIONARY DAY SIGNALS.

Southerly Gale. The Cone *point downwards* means that strong winds are probable, at first from the Southward (from S.E. round by S. to N.W.).



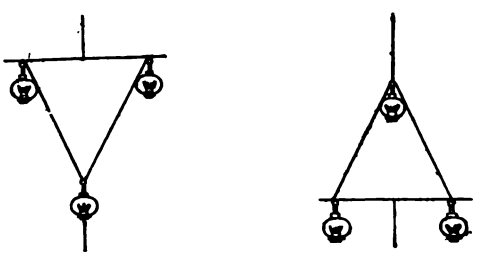
Gale probably from the Southward.

Northerly Gale. The Cone *point upwards* means that strong winds are probable, at first from the Northward (from N.W. round by N. to S.E.).



Gale probably from the Northward.

NIGHT SIGNALS.



Three lanterns and one yard, four feet long, will be sufficient.

These Signals may be made with any lanterns, showing white or any colour, but *alike*. Red is best. Lamps are better than candles. The halliards should be good rope, and protected from chafing. The lanterns should hang at least three feet apart.

Sudden Shifts of Wind.—No Signal is employed to indicate a wind which is likely to shift suddenly, but it must be remembered that a Southerly wind is much more likely to veer to a point North of West than a Northerly wind is to veer to a point South of East; accordingly, when the South signal cone is hoisted, and the anchorage or harbour is exposed to the North-West, it is advisable to make preparations for a North-West gale.

On Hoisting the Signals.—The Signal is to be kept flying until dusk, then lowered, and hoisted again next morning; and so on until the end of 48 hours from the time the message has been issued from London (which is always marked on the telegram), unless orders are received previously to lower the signal.

Night Signals.—At dusk, whenever a Signal ought to be flying if it were daylight, a Night Signal may be hoisted in place of the Cone, consisting of three lanterns hung on a triangular frame, point downwards, or point upwards, as the case may be. They should be kept burning until late in the evening, say 9 or 10 o'clock.

Meaning of Signal.—The hoisting of any of these Signals is intended as a sign that there is an atmospherical disturbance in existence in the neighbourhood which will *probably* cause a gale from the quarter indicated by the Signal (say, within a distance of fifty miles of the place where the signal is hoisted), the knowledge of which is likely to be of use to the sailors and fishermen on that part of the coast. Its meaning is simply, "Look out! It is probable that bad weather of such and such a character is approaching you."

Hitherto it has been found that at least *three* out of *five* Signals of approaching storms (Force, upwards of 8 Beaufort scale, a "Fresh Gale"), and *four* out of *five* Signals of approaching strong winds (Force, upwards of 6 Beaufort scale, a "Strong Breeze"), have been fully justified.

In every case some of the principal reasons which have led to the hoisting of the Signal are explained in the telegram, *which should always be kept posted up for public inspection while the signal is flying.*

It must be remembered that only the greater and more general disturbances of the atmosphere can be made known by this method. Local changes of less extent may be indicated to observers by their own instruments and by local signs of weather, etc.

A regular study of the Daily Weather Report will be found very useful, as showing what weather has lately been prevalent generally.

The Signal will sometimes be kept flying after the gale is over; this is the case because often one gale is followed by another before the forty-eight hours are out. In every case when it is thought at the Meteorological Office that immediate danger is over, orders are issued to lower the Signal.

Supply of Weather Intelligence.—A copy of the Daily Weather Report, with Chart, will be supplied by post, free of cost, to any port where the authorities will undertake to exhibit it to the public as soon as received. The subscription for a copy for private use is one pound a year, to cover the cost of postage.

The office is prepared to send occasionally by telegraph to any port, any information which may have reached the office, and which the authorities at the port may wish to have, if these authorities will bear half the expense of transmission of the messages. This intelligence is quite independent of the warnings; these are transmitted free.

Statements as to the weather at certain points of the Coast, whenever there is any disturbance of consequence of the atmosphere, but not amounting to a storm, may be cited as examples of the kind of information which might be supplied. These statements might be telegraphed, when necessary, to the ports. Such messages ought to reach the port, at latest, at about noon on any day that they are issued. The system, wherever tried, has been found to be useful.

Information as to the laws of weather will be found in the "Board of Trade Barometer Manual," ed. 1871 (price 1s.), in the "Board of Trade Fishery Barometer Manual," ed. 1869 (price 6d.), and in "Aids to the Study and Forecast of Weather," by W. Clement Ley, M.A., ed. 1880 (price 1s.).

Storm Signals established by Foreign Countries.

France.

The Minister of Marine sends telegrams to the ports and semaphore stations announcing when any dangerous atmospheric disturbance may be expected. On receipt of such a telegram it is posted in some convenient place and a cone is hoisted as in this country.

The following Weather Signals are also in use on the coasts of France :—

A Square Flag of any colour.	"*Doubtful weather. The barometer is inclined to fall.*"
A Burgee of any colour.	"*Appearance of foul weather. Heavy sea. Barometer is falling.*"
A Pennant of any colour.	"*Appearance of better weather. Barometer is rising.*"
A Square Flag above a Burgee.	"*The entrance of the port is becoming dangerous. Take care.*
A Square Flag under a Burgee.	"Lifeboat is coming."

Germany.

1. The Drum and Cone as formerly used in England, and in addition :—

2. A Black Ball indicating a *disturbance* and as a symbol calling attention to the telegram. *One* red flag over the Ball indicates "wind likely to veer." *Two* red flags over the Ball indicates "wind likely to back."

Italy.

Telegrams are sent to the various Semaphore and Signal Stations on the coast announcing grave indications of bad weather, and the Drum and Cone as formerly in use in England are hoisted as signals.

The Netherlands.

Information is posted up on black boards, and in addition an instrument called an Aëroclinoscope, designed to indicate the difference of atmospheric pressure, has been erected at all the ports.

The following description is issued by the Director of the Royal Meteorological Institution of the Netherlands :—

Experience teaches us that, whenever the atmospheric pressure is greater in the north of our country than in the south, an east wind follows, and the reverse whenever the atmospheric pressure is higher in the south than in the north, a west wind ensues. Is the atmospheric pressure higher in the south-east than in the north-west, a south-west wind is the result.

Generally the wind falls nearly perpendicularly on the line connecting the place where the atmospheric pressure is highest with that where it is lowest, and from the left hand, looking from the former place to the latter.

The power of the coming wind depends on the greatness of the difference of pressure, and the wind will be stronger where the barometer is lowest.

If the atmospheric pressure is four millimetres higher in the southern ports of our land than in the northern, in seventy-five cases out of a hundred, the wind will acquire a force of from twenty-five to thirty kilogrammes on the square yard.

In summer this is generally followed by heavy rains without much wind. South-west winds generally follow one or two days after this difference has been observed. On the contrary, north-west winds generally follow some hours after this difference.

If the pressure is higher in the north than in the south, and in the course of twelve or twenty-four hours the reverse takes place, the pressure becoming higher in the south than in the north, so that the total difference amounts to four millimetres, caution is required; the situation is unfavourable. For instance, if in the morning the pressure at Groningen is two millimetres higher than at Maastricht, and in the evening two millimetres higher at *Maastricht* than at *Groningen*, the total difference is four millimetres.

In consequence of the general eastward movement of the atmosphere, the east wind, in our latitude, is not so strong as the west.

It is, however, necessary to notice the height of the barometer; for this is of influence, though it is only of a secondary nature.

As we not only inquire after the state of the barometer, but whether it is rising or sinking; so we must compare the greatest difference in the atmospheric pressure of to-day with that of yesterday.

In the Netherlands these observations are taken at *Groningen*, *Helder* (Nieuwediep), *Vlissingen*, and *Maastricht*.

In our indication, for brevity's sake, only the initial letters of these places are given. G stands for *Groningen*, V for *Vlissingen* (Flushing), etc.

Is the pressure from 2·5 millimetres higher at *Vlissingen* than at *Groningen*, this fact is stated thus:—V 2·5 G, the name of the place where the pressure is highest being placed first.

At eight in the morning and six in the evening, the state of the barometer

is sent by telegraph to *Utrecht*, on which the difference in the atmospheric pressure is ascertained and transmitted by signals to the different seaports.

To make this difference visible, an instrument called an Aëroclinoscope, which indicates the latest difference observed in the atmospheric pressure, has been put up at *Vlissingen*, *Zierikzee*, *Brouwershaven*, *Hellevoetsluis*, *Rotterdam*, *Amsterdam*, *Nieuwediep*, and *Harlingen*.

Description of the Instrument.

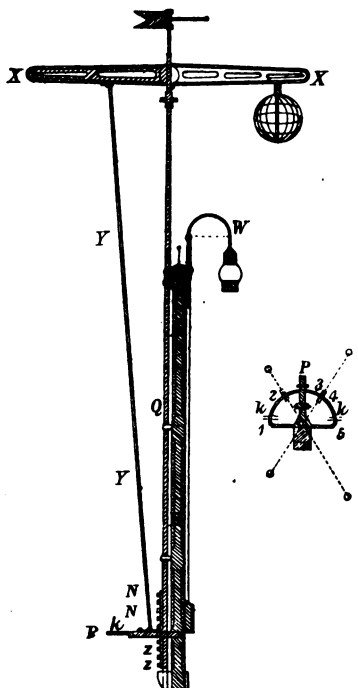
To the post A B is attached an iron tube Q Q, bearing the movable arm X X.

By means of the lever P the tube and arm are moved, and may be so fixed as to be parallel to the line connecting the two places in which the observations indicated are taken; the notches in the iron band K K are so constructed as to correspond to all the various combinations, resulting from the communications from the four places indicated. For instance, the five notches running from the left to the right hand, denote:—

1st V—M. 2nd H—M. 3rd V—H.
H—G. M—H. H—V.
M—G.
G—M.
4th V—G. 5th M—V.
G—V. G—H.

An iron rod Y Y attached to the arm X X regulates its incline.

The rod Y Y is attached by iron pins to the tube Q Q. To the pins N N when the north is uppermost, and to the pins Z Z when the South is uppermost.



One-half of the arm X X is painted red, and the other half white.

The red half has two apertures in it, and points to the North; the white half has three apertures in it, and points to the South.

The ball K is suspended to the white part of the arm; the northern half of the ball is painted red, the southern white. The colour of the ball serves mainly to indicate which part of the ball is uppermost or undermost.

The colours of the ball, as the apertures in the arm, merely serve to make it more apparent at a distance which part of the arm is turned towards us, when we view it obliquely.

Whenever the right signal is unfavourable, a lamp is suspended at dusk to the curve W, and kept burning till daylight, and the arm is distinctly visible.

Norway.

At the Semaphore Station Oxö, Storm-warning Signals, like those in use in England, are hoisted.

Portugal.

Drum, Cone, and Night Signals, as formerly in use in England.

Russia.

As above.

United States.

The observers at the Signal Stations, Lighthouses, etc., on the coasts of the United States are practised in the Army and Navy Signal Codes, in the use of Semaphores, and in the International Code of Signals, by which they are prepared to hold communication with vessels of any nation at sea coming within signal distance.

It is so arranged that any question as to weather changes anticipated so signalled from the vessel to the shore station is immediately transmitted by telegraph to the central office, whence a prompt reply is returned. This reply, on reaching the coast station, is signalled by flags to the inquiring vessel.

The case may be imagined of a vessel sailing from New York for a southern port, and making inquiries off the Capes of the Delaware whether

it will be safe to pass Cape Hatteras, and advised from the main office that a storm at the time is moving near Hatteras, and to take shelter at the Delaware Breakwater until the disturbance shall have passed northward.

Two classes of signals, the CAUTIONARY SIGNAL, and the CAUTIONARY OFF-SHORE SIGNAL, are in use.

The CAUTIONARY SIGNAL, *i.e.* a red flag with black square in the centre by day, or a red light by night, calls for caution in view of an approaching storm, and is so "cautionary" with reference to winds blowing from any direction.

The CAUTIONARY OFF-SHORE SIGNAL, *i.e.* a white flag with black square in the centre, shown above a red flag with black square in the centre, by day, or a white light shown above a red light by night, is "cautionary" with reference to winds expected to blow from a northern or western direction, or off shore, at or near the place at which it may be displayed.

The display of this Signal will often follow, and must be distinguished from, the usual "cautionary signal," which retains, whenever shown alone, its usual meaning. The display of either Signal is cautionary.

The display of cautionary signals, by flags by day, and lights by night, is made on occasions of supposed especial danger, at the stations given on page 29, and also at a number of stations on the Lakes.

The occurrence of a storm area registering a wind velocity of twenty-five miles per hour on land, indicating a much greater velocity at ten or twenty miles from the land, is taken as the lowest velocity justifying a signal.

SECTION II.

THE STANDARD COMPASS.

THE STANDARD COMPASS.

Instructions for the use of the Admiralty Standard Compass.

THIS instrument is so constructed as to answer the purpose of a Steering Compass and an Azimuth Compass.

The chief points in its construction are the following:—

1. The *bowl* is of stout copper, with the view to calm the vibrations of the needle, and the intersecting point of the axes of its gimbals is made to coincide with the point of suspension of the card, and also with the centre of the azimuth circle.

2. In observing amplitudes and azimuths, the bearings are read from the card without reference to the azimuth circle, the card being graduated to twenty minutes of arc. The *azimuth circle* is graduated to minutes of arc, and may be used on shore for surveying purposes. When so used, and when accurate magnetic bearings are required, the zero of the circle may be adjusted to the magnetic north, shown by the card, then clamped, and any number of magnetic bearings may then be obtained round the circle. Or by adjusting the zero of the circle to any given object, and clamping the compass to its stand, the angles of objects round the horizon may be observed and read off to the nearest minute.

3. The *magnetic needles* employed are compound bars, formed of laminæ of that kind of steel (clock-spring) which has been ascertained by numerous experiments to be capable of receiving the greatest magnetic power. Each compass has two cards, A and J; the former is generally used, but in stormy weather, with much motion in the ship, the heavy or J card is substituted.

Each *card* is fitted with four needles fixed vertically and equi-distantly on a light framework of brass screwed to the card; the pair of central needles

are 7·3 inches long, and the pair of external ones 5·3 inches, the whole weight of the A card being 1525 grains.

The extremities of the needles are 15° and 45° from the extremities of the diameter of the card which is parallel to them.

Two of the pivots for card A are pointed with "native alloy," a material which is harder than steel, and which does not corrode by exposure to the atmosphere; and the ruby and agate caps are worked to a form to suit these points.

Two spare pivots pointed with hardened steel are likewise supplied, and these are gilded by the electrical process.

The two ruby-headed pivots are made exclusively for the heavier card J, *and no other kind of pivot is to be used with this card.*

4. The *impressions of the cards* are taken after the paper has been cemented to the mica plate forming the basis; distortions from shrinking are thus prevented, and a more perfect centering attained.

The zero points of the cards and the magnetic axes of the needles are adjusted to each other with great care at the Compass Observatory for Her Majesty's Navy at Deptford. The various adjustments for centering, and the elimination of errors due to the displacement of sight vanes and prism, are always made at this observatory, the compass being afterwards supplied to H.M. ships free from error.

1. When used as an Azimuth Compass.

This compass may be converted to this purpose by removing the steering cover, and fixing on the azimuth circle.

In observing amplitudes and azimuths at sea, the bearings are read from the card, without reference to the external graduated circle.

2. When used either as an Azimuth or Steering Compass.

Be very careful to preserve the *pivot point* from injury when screwing the pivot into the bowl; and place the card gently upon it: and never move the compass without first having lifted the card (by means of the side screw) against the centre-pin. This pin is so contrived as to leave the card entirely free when in its level or proper position, and it cannot touch any part of the collar, except under some violent motions of the ship, for which the gimbals do not compensate.

The pivots, caps, and margins of the cards should be examined occasionally to see that their free working is not impeded by dust or fibres from the paper. When card A is not sufficiently steady, the heavy card J is to be used with one of *its own ruby-headed pivots.*

Whenever the card works sluggishly, or whenever injury by accident or long wear be suspected, a new cap or pivot should be screwed in, or (as the case may be) card J with its appropriate pivot may be used. The central cap-screw, or nut on the face of the A card, must be taken off before the ruby cap is attempted to be unscrewed.

The cards should be adjusted for dip by the balancing slides when necessary. When the bowl does not work freely on its gimbals, the axes and their bushes should be examined and slightly rubbed with plumbago.

Caution.

Experience having proved that both the pivots and caps of the A card, as also the ruby-headed pivot of the J card, have received injury by the concussion arising both from the firing and exercise of heavy guns in the vicinity of the compass, it is especially enjoined that the card should on these occasions (unless it is very inconvenient to do so) be lifted off the pivot by the apparatus at the side of the bowl.

Should it be necessary to remove the prism for the purpose of cleaning it from dust or moisture, the cover is arranged to slide upwards on guides, and can easily be removed and replaced by hand, taking care in replacing the prism that the lens or rounded part is placed below. All the screws attached to the prism plate have received special adjustment, and must not, therefore, be altered.

The seaman is warned against the use of very large compass cards where the needles are twelve inches long, and in some cases even longer.* Such cards although they are *read* more accurately that smaller ones, are far less *accurate* in their performance. The size of the needles on the Admiralty Standard Compass card (7·3 inches), as also their arrangement, was the result of extensive study by a committee of competent authorities. Many years' trial has shown that the Admiralty Standard Compass is a reliable instrument, suited for all purposes of navigation. The Standard Compass invented and patented by Sir Wm. Thomson also possesses considerable advantages, and is much used in H.M. ironclad ships, and the vessels belonging to the Mercantile Marine.

* This caution does not apply to compass cards constructed on the principle invented by Sir William Thomson.

The Standard Compass should be placed as far as possible from any considerable mass of iron, and should not be within ten feet of the extremity of any elongated mass of iron, *especially if vertical*, such as the spindle of the capstan, iron stanchions, iron quarter-davits, iron funnels, iron masts, iron jackstays or trysail booms, wire topping lifts, transverse iron bulkheads,* and not less than five feet above the deck. When of necessity the compass is placed far aft, in an iron ship, it should not be within half the width of the ship from the stern-post or rudder-head.

No stand of arms or other iron, *subject to occasional removal*, should be placed within at least fourteen feet of this standard compass, whether on the same deck, or immediately below it.

By the Standard Compass the course should be set, and bearings to determine the ship's position obtained. For this purpose it must be placed where an *all-round* view of the horizon can be had, masts or funnels alone intervening. The binnacle must be firmly and securely bolted to the deck, so as to prevent vibration in strong winds or with much motion. On taking command of a ship, one of the first duties of the captain should be to see that the lubber point of the Standard Compass be exactly in a true fore and aft line.

When the ship is ready for sea, and with davits and other iron work secured in the positions in which it is intended they shall remain at sea, *then* the deviation of the Standard Compass from the magnetic meridian should be ascertained by one of the following methods :—

Process by Bearing of a Distant Object.

The requisite warps being prepared, the ship is to be gradually swung round, so as to bring her head successively upon each of the thirty-two points of the compass; and as her head approaches each of these points, so gently to check her motion as to prevent any continued swing of the card. When the ship is quite steady, and her head exactly on any one point, the direct bearing of some distant but well-defined object is to be observed with the Standard Compass, and registered.

The ship's head is then to be gently warped round in the same manner to the next point, and when duly stopped and steadied there, the bearing of the same object is to be again taken and again recorded; and so on, point after point, till the exact bearing of the one object has been ascertained with the ship's head on every separate point of the compass.

* Shipbuilders should pay particular attention to this most important point, viz. the position of the Standard Compass.

The object selected for that purpose should be at such a distance from the ship, that the diameter of the space through which she revolves shall make no sensible difference in its real bearing. If she be at anchor in a tideway, a steeple or a detached house, a large single tree, at not less than from six to eight miles distance, will well answer the purpose; but if in a basin, a less distance will suffice.

The next step is to determine the *correct* magnetic bearing of the selected object from the ship; or, in other words the compass bearing which it would have from on board, if the compass were not disturbed by the attraction of the iron in the ship. This may generally be effected by taking the mean of all the observed bearings, if observed on equi-distant points; or of four or more bearings, if observed also on equi-distant points; but a surer result will be obtained by carrying the Standard Compass to some place on the adjacent wharf or shore, taking care that there is no iron in the vicinity, from whence the ship (that is to say, the part of the ship where the compass stood) and the distant object, of which the bearings had been observed, shall both be exactly in one line with the observer's eye. The bearing of the object from that point will evidently be the same as its *correct* magnetic bearing from the ship by that compass. The difference between this *correct* magnetic bearing of the object, and the bearing observed with the Standard Compass on board, when the ship's head is on any particular point, will show the error caused by the ship's iron on that point, or in other words, the *Deviation* of the Standard Compass, according to the direction in which the ship's head was placed.

Process by Azimuths and Amplitudes of the Sun.

With the aid of those essentials to safe navigation, Burdwood's Tables,* and Davis's Tables,† the sun's true bearing can be obtained by inspection, if the apparent time at ship, the latitude and declination be known. The difference between the sun's *true* bearing and the sun's *compass* bearing (as observed with the ship's head on any particular point of the compass) is the *total error*, i.e. the amount of the ship's deviation on that particular point, combined with the variation of the compass due to the geographical position. By deducting the latter from the difference of bearings observed, the deviation is obtained.

* The Sun's True Bearings, or Azimuth Tables, computed for intervals of four minutes, between the parallels of lat. 30° and 60° inclusive, by the late Staff-Commander John Burdwood, R.N., Naval Assistant in the Hydrographic Department, Admiralty.

† The Sun's True Bearings, or Azimuth Tables, computed for intervals of four minutes, between the Equator and 30°, by the late Captain J. E. Davis, R.N., Naval Assistant, Hydrographic Department, and Mr. P. L. Davis, "Nautical Almanack" Office.

By this process, during the course of a voyage, especially near sunset or sunrise and with a tranquil sea, a deviation table can be formed by steaming, or tacking and sailing round a circle, in the course of half an hour. The ship should be kept upright in order to avoid heeling error.

Process by Reciprocal Bearings.

Should there be no suitable object visible from the ship, and at the requisite distance as stated above, the deviations must be ascertained by the process of Reciprocal Bearings. A careful observer must go on shore with a second compass, and place its tripod in some open spot, taking care that there is no iron in the vicinity, where it may be distinctly seen from the Standard Compass on board. Then, by means of preconcerted signals, the mutual bearings of those two compasses from each other are to be observed at the moment when the ship's head is quietly steady on each of the thirty-two points successively, as before directed.

To ensure the success of this operation, the compass on shore should not be more distant from the ship than is consistent with the most distinct visibility with the naked eye of both compasses from each other. The observations should be made as strictly simultaneously as possible. And to guard against any mistake, such as might be occasioned by a signal being misinterpreted, the time at which each bearing is taken should be noted, both on shore and on board, by compared watches.

Before this practice is complete, the Standard Compass should be carried on shore, in order to be compared with the compass which had been employed there, by means of the bearing of some distant object; and the difference, if any, is to be recorded. This comparison of the two compasses may as well be made previously to the observations; and in all cases when compasses are compared, the caps, pivots, etc., should be first carefully examined.

During either of the processes for ascertaining the deviations of the Standard Compass, when the ship's head pauses at each point, it is desirable to note, in a separate Table, the corresponding directions of her head shown by the so-called Binnacle Compasses, placed near the helm, or by which the vessel will actually be steered.

In steam vessels fitted with telescopic funnels, and when from necessity the Standard Compass is placed near to the steam machinery, the deviation is materially altered by the elongated or compressed state of the funnel. For instance, with her head east, H.M.S. *Blenheim* has 9° deviation with the funnel *up*, and 15½° when *down*. In H.M.S. *Vulcan* (of iron) there is a contrary result. In swinging vessels, therefore, so fitted, and when the funnel

is within thirty or thirty-five feet of the compass, it is necessary that on the eight principal points of the compass, at least, the deviations should be ascertained in both conditions of the funnel.

The mariner must remember that the corrections found for the Standard Compass belong to that compass alone, and to that compass only while it is in its proper place; and that those corrections will furnish no guide whatever to the effects of the ship's iron on a compass placed in any other part of the ship. It is essential, therefore, that the ship's course should not only be *invariably* directed by the Standard Compass, but that all the courses and bearings inserted in the log should be those shown by that compass alone; the Binnacle Compass being regarded solely as a guide to the helmsman. When the ship has been placed on her proper course by the Standard Compass, the helmsman will notice the point shown by the Binnacle Compass as being that to which *he* has to attend; and a comparison of the two Compasses should be frequently repeated by the officer of the watch or the quartermaster, and should always be made when any alteration occurs in the direction of the course, or when the ship heels over. When the ship is by the wind, the apparent course by the Standard Compass is that which must be inserted in the log.

Heeling Error.

Experience has shown that the deviations in iron vessels (also in wood-built vessels with iron beams) are affected by the heeling of the ship; the magnitude of the error so resulting being proportional to the amount of heel. The *maximum* disturbance when heeling, occurs when the ship's head is *north* or *south*, by the observing compass, the disturbance vanishing when the ship's head is *east* or *west* by the observing compass.

It becomes, therefore, an early duty of those in charge of iron ships to ascertain by repeated observations at sea the degrees of error arising from the various conditions of heeling both to starboard and to port.

On the Mechanical Correction of the Deviation of the Compass.

The Deviation of the Compass on board an iron ship is composed of three parts, namely, the *Semicircular* Deviation, the *Quadrantal* Deviation, and the *Heeling* Error.

The Semicircular Deviation in a well-placed compass (see p. 44) is due chiefly to the permanent magnetism acquired by the ship while building: the ship herself is a magnet, the direction of the magnetism of

which, as affecting the compass, may be inferred from the direction in which the ship's head was while being built.* It necessarily follows that the points of maximum semicircular deviation are at right angles to the direction of the ship's head in building: thus, in a ship built head north, the points of maximum semicircular deviation are at east and west, and there will be no such deviation at north and south. In a ship built head west, the points of maximum semicircular deviation will be at north and south, and there will be no such deviation at east and west.

As in the majority of cases, the ship's magnetic force causing the semicircular deviation acts in a direction diagonal to the ship's fore and aft line, it is convenient to consider the ship's force as made up of two forces† one acting in a fore and aft direction and producing a deviation named B, the other acting in an athwartship direction and producing a deviation named C; B and C, therefore, constitute the semicircular deviation.

The only way of destroying the effect of one magnetic disturbing force, is to introduce another magnetic disturbing agent whose force follows the same laws and has the same magnitude, but always acts in the opposite direction, or in other words, the effects of hard iron must be corrected by hard iron, and the effects of soft iron by soft iron.‡ If therefore in the semicircular deviation B and C are known, the direction in which the counteracting force should be introduced can readily be determined, and the deviation be corrected.

BY A SINGLE MAGNET.

This method is usually adopted in the Royal Navy; it is especially convenient for Standard Compasses, which, occupying favourable positions are subject only to small changes of deviation. The following process is required:—Place the ship's head East by compass and observe the deviation; this deviation is approximately the value of B, marked + if the deviation be easterly, and − if westerly; then place the ship's head North, and the deviation on that point is the approximate value of C, marked + if the deviation be easterly, and − if westerly. Enter the traverse table with B as diff. lat. and C as departure, and take out the course and distance. The course indicates

* The direction of the ship's magnetic force coincides nearly with the line drawn on the deck in a magnetic north and south direction. Thus, in a ship built head N.E., the line of the ship's magnetic force will point at an angle of 45° on the port bow.

† By the well-known theorem of the parallelogram of forces.

‡ Permanent magnets are necessarily made of hard iron.

the inclination to the fore and aft line at which the correcting magnet must be placed, and the distance, the amount of semicircular deviation to be corrected. The position the correcting magnet should occupy may be found by taking a compass on shore and placing the magnet in an East and West direction with its centre due North or South from the compass, and moving the magnet to or from the compass until it produces a deflection equal to the semicircular deviation which is to be corrected. At the distance thus determined the magnet should be placed with its centre directly below the centre of the compass card, parallel to the plane of the deck, and with its edge upwards. The magnet, however, should not be nearer to the centre of the card than twice the length of the needle, but if necessary a stronger magnet should be used.

If the Semicircular Deviation consist of

+ B and + C	the North end of the magnet should point on the Starboard bow.
+ B and − C	" " " " Port bow.
− B and + C	" " " " Starboard quarter.
− B and − C	" " " " Port quarter.

EXAMPLE:—The deviation of a compass on board H.M. iron-clad ship *Achilles*, head East, is 19½° Easterly; head North, 5½° Easterly.

Entering the traverse table with + B 19·5 as diff. lat. and + C 5·5 as departure, the course thus found is 16°, and the distance, the amount of semicircular deviation to be corrected, is 20. The north end of the magnet should therefore point on the starboard bow at an angle of 16° with the fore and aft line. With a 10-inch magnet, such as is used in the Royal Navy to correct the Standard Compass, the distance will probably be 1 ft. 8 in. below the card.

Again:—The deviation of the compass on board H.M. iron-clad ship *Royal Oak*, head East, is 10° Westerly; head North, 9° Easterly. Entering the traverse table with − B 10 as diff. lat. and + C 9 as departure, the course thus found is 42°, and the distance 13½. The north end of the magnet should therefore point on the starboard quarter at an angle of 42° with the fore and aft line. The 10-inch magnet mentioned will probably have to be placed at a distance 1 ft. 10 in. below the card.

The value of B can be more correctly obtained by taking the mean of the deviations at East and West, the latter deviation with the sign changed; and of C by taking the mean of the deviations at North and South, the latter deviation with the sign changed; but for the general purposes of compass correction, the values of B and C as determined from the deviations on two adjacent cardinal points is sufficiently correct.

BY TWO MAGNETS.

This is the method almost universally adopted in the Mercantile Marine: it is by far the most easy plan of correcting ship's compasses, as it requires no calculation—the operation in fact is purely mechanical. Place the ship's head East or West, correct magnetic; then place a magnet in a fore and aft direction with the middle of the magnet's length in the vertical plane, passing athwartship through the centre of the compass card; move the magnet nearer or farther off until the compass points correctly: that part of the semicircular deviation called B (produced by the fore and aft force) is thus corrected. Similarly with the ship's head North or South, correct magnetic, place a magnet athwartships parallel to the deck, with the middle of the magnet's length in the vertical plane, passing fore and aft through the centre of the compass; move the magnet nearer or further off until the compass points correctly; that part of the semicircular deviation called C (produced by the transverse force of the ship) is thus corrected. The B, or fore and aft, magnet may be placed either on the port or the starboard side of the compass, and the C magnet either on the fore or after side of the compass; but neither magnet should be in the same horizontal plane as the card, nor should either be within twice the length of the compass needle from the centre of the compass card. The magnets may be conveniently secured to the deck or to the sides of binnacle if necessary; but precautions are requisite if the magnets are on the deck, that they be not reversed after caulking the deck.

Care should be taken that the ship be on an even keel while the compasses are being corrected.

The mariner is cautioned that a rapid change takes place in the magnetism of ships newly launched, and the magnets in such cases will require re-adjusting. Also in compasses unfavourably placed, the magnets will require re-adjusting on a considerable change of geographical position.

It is important to know that the semicircular deviation of the compass, corrected or uncorrected in an iron ship, alters when the vessel has lain a long time on the same course, or has lain a long time with her head in one direction in a dock or alongside a wharf; the amount of such error is often serious, and depends on the nature of the iron of which the ship is composed. *Unceasing observation* is therefore the only safeguard.

The Quadrantal Deviation of the compass is due solely to the soft iron of the ship. The earth's magnetic force induces in the soft iron a magnetic force which produces the greatest effect when the ship is on the quadrantal points, namely N.E., S.E., S.W., and N.W., and none when she is

on the cardinal points; it is therefore named Quadrantal Deviation. Such deviation is caused chiefly by the iron beams of the ship, and in the majority of cases it is easterly when the ship's head points in the N.E. and S.W. quadrants, and westerly when in the N.W. and S.E. quadrants; its amount does not, except in some iron-clad ships, usually exceed 5° or 6°. Quadrantal deviation has this singular property, namely, that it does not change either with change of geographical position or by lapse of time.

To find the amount of the quadrantal deviation, take half the algebraic sum of the deviations on the N.E. and S.W. points; thus, in H.M.S. *Achilles* the deviation at N.E. is 24° 10′ E. (marked +), the deviation at S.W. is 10° 30′ W. (marked −); half the algebraic sum of + 24° 10′ and − 10° 30′ is + 6° 50′. To find the quadrantal deviation from the deviations on the N.W. and S.E. points, the signs of both quantities must be changed: thus, in the *Achilles* the deviation at N.W. is 19° 30′ W. (or −), at S.E. 6° E. (or +); half the algebraic sum of + 19° 30′ and − 6° is + 6° 45′. A more accurate value of the quadrantal deviation would be the mean of + 6° 50′ and + 6° 45′ or + 6° 48′.

Adopting the principle already mentioned of "like curing like," we must, as the quadrantal deviation is caused by soft iron, correct it by soft iron. This correction, although perfect in theory, is not easy in practice, owing to the difficulty of getting iron magnetically "soft" or free from permanent magnetism, and also from the close proximity to the compass which the correctors must occupy. From these causes, as well as from the fact that the quadrantal deviation is unvarying and usually of moderate amount, correction for quadrantal deviation is not often applied. The object of the mechanical correction of the compass being not an attempt at rigorous accuracy, but to bring the deviation within manageable limits.

The best correctors of large quadrantal deviations, are a couple of hollow cast-iron globes or shells, as introduced by Sir W. Thomson, placed on a level with the compass needle.

The Heeling Error.—Brief remarks have already been made on the heeling error (p. 47).

The Heeling Error is caused (1) by the vertical force of the ship's magnetism which was acquired while building; (2) by vertical induction in vertical soft iron; and (3) by vertical induction in the beams which are also soft iron. As a general rule, in ships built in England the north end of the needle, when the ship heels, is drawn to windward or high side of the ship, and the heeling error is therefore said to be to windward; but in some ships, notably those built with their heads to the southward, S.W. to S.E., the

heeling error is to leeward. Ships, therefore, having a heeling error to windward, will, on Northerly courses, be to windward of their reckoning, and on Southerly courses to leeward. Those having a leeward heeling error, the reverse is the case.

The Heeling Error occasionally amounts to 1½° and even 2° for each degree of heel when the ship is on a North or South course: with the ship's head in any other direction this amount will have to be multiplied by the cosine of the course; thus steering N. 60° E. the heeling error, with the same amount of heel, will be half the amount produced on a north course; for cosine of 60° = one half radius. On proceeding to south latitudes, those vessels which had a windward heeling error in north latitudes will have their heeling error much diminished and possibly reversed; whereas those which had a leeward heeling error in north latitudes, will have it much increased on proceeding to south latitudes.

The mechanical correction of the heeling error is made by a magnet placed in a vertical position under the centre of the compass card, at such a distance as shall be found suitable. This distance may be determined by heeling the ship about 10°, with her head in the direction which was North by compass when she was upright. Then place the magnet very accurately in its position perpendicular to the ship's deck—with windward heeling error the north end of the magnet should be uppermost, with leeward error the south—raise or lower the magnet until the compass points correctly. The distance of the vertical magnet may be found while the ship is upright, but by experiments and calculations which are too complex to enter upon here.

Owing to the fact that the effects of soft iron are corrected by a permanent magnet (hard iron) the correction for heeling error is only perfect while the ship remains in the magnetic latitudes; and a ship in England corrected for a windward heeling error may be found, on proceeding to south latitudes, to have a large leeward heeling error.

Many valuable ships have been lost through unknown or unallowed heeling errors. Heeling error is the navigator's great bugbear, and demands his unceasing attention.

N.B.—*As the correcting magnets do not remove the whole of the Deviation of the Compass, the ship should be swung after the magnets have been fixed in their places, to ascertain the remaining deviation.*

Wooden and Composite Built Ships.

The previous remarks on the mechanical correction of the ship's compass have referred entirely to iron ships. In wooden sailing ships the points of maximum deviation of the compass are at East and West; their deviation, which is small, arises from induced magnetism in vertical iron, the effect of which varies as the tangent of the dip of the needle. In the northern hemisphere the deviation is Easterly on Easterly courses, and Westerly on Westerly courses; in the southern hemisphere the reverse is the case.

In wooden steam ships where the machinery and boilers are before the compass the deviation of the compass in the northern hemisphere is of the same character as that of wooden sailing ships in the northern hemisphere; but the changes that occur in the deviation of the former are not the same as in that of the latter. In the southern hemisphere the deviation of wooden steam ships is of the same character as in the northern hemisphere, but much reduced in amount. This is owing to the permanent attraction exercised by the machinery.

Composite-built ships (those with iron beams and iron ribs) follow generally the same laws in the deviations of their compasses as do iron ships.

Those who require a more extensive knowledge of the deviation of the compass than can be given in the brief space allotted in a pocket-book, are referred to the following works, namely: *Admiralty Manual of the Deviation of the Compass*, 4th Ed., Lond., 1874; *Manual for the Deviation of the Compass*, by Captain F. J. Evans, R.N., Lond., 1870; *Practical Information on the Deviation of the Compass*, for the use of Masters and Mates in Iron Ships, by J. T. Towson, Esq., Lond., 1869; *Syllabus of a Course of Lectures on Magnetical Errors, Compensations, and Corrections*, by G. B. Airy, Esq., Astronomer Royal, Lond., 1866; *Wrinkles in Practical Navigation*, by S. J. S. Lecky, R.N.R., Lond., 1881; and last, but not least, the *First, Second, and Third Reports of the Liverpool Compass Committee to the Board of Trade*, 1855, 1856, *and* 1861.

DEVIATION TABLE, H.M.S.

Ship's Head *by Standard Compass.*	Deviation at	Deviation at	Deviation at	Deviation at
NORTH.				
N. by E.				
N.N.E.				
N.E. by N.				
N.E.				
N.E. by E.				
E.N.E.				
E. by N.				
EAST.				
E. by S.				
E.S.E.				
S.E. by E.				
S.E.				
S.E. by S.				
S.S.E.				
S. by E.				
SOUTH.				
S. by W.				
S.S.W.				
S.W. by S.				
S.W.				
S.W. by W.				
W.S.W.				
W. by S.				
WEST.				
W. by N.				
W.N.W.				
N.W. by W.				
N.W.				
N.W. by N.				
N.N.W.				
N. by W.				

STEERING TABLE, H.M.S.

Magnetic Course proposed to be made.	Course therefore to be steered by Standard Compass, in order to make the proposed Correct Magnetic Course.
NORTH.	
N. by E.	
N.N.E.	
N.E. by N.	
N.E.	
N.E. by E.	
E.N.E.	
E. by N.	
EAST.	
E. by S.	
E.S.E.	
S.E. by E.	
S.E.	
S.E. by S.	
S.S.E.	
S. by E.	
SOUTH.	
S. by W.	
S.S.W.	
S.W. by S.	
S.W.	
S.W. by W.	
W.S.W.	
W. by S.	
WEST.	
W. by N.	
W.N.W.	
N.W. by W.	
N.W.	
N.W. by N.	
N.N.W.	
N. by W.	
North.	

Archibald Smith's (Straight Line) Course Table.

Standard Compass Courses.	Correct Magnetic Courses.
NORTH.	NORTH.
N. by E.	N. by E.
N.N.E.	N.N.E.
N.E. by N.	N.E. by N.
N.E.	N.E.
N.E. by E.	N.E. by E.
E.N.E.	E.N.E.
E. by N.	E. by N.
EAST.	EAST.
E. by S.	E. by S.
E.S.E.	E.S.E.
S.E. by E.	S.E. by E.
S.E.	S.E.
S.E. by S.	S.E. by S.
S.S.E.	S.S.E.
S. by E.	S. by E.
SOUTH.	SOUTH.

Standard Compass Courses.	Correct Magnetic Courses.
SOUTH.	SOUTH.
S. by W.	S. by W.
S.S.W.	S. S.W.
S.W. by S.	S.W. by S.
S.W.	S.W.
S.W. by W.	S.W. by W.
W.S.W.	W.S.W.
W. by S.	W. by S.
WEST.	WEST.
W. by N.	W. by N.
W.N.W.	W.N.W.
N.W. by W.	N.W. by W.
N.W.	N.W.
N.W. by N.	N.W. by N.
N.N.W.	N.N.W.
N. by W.	N. by W.
NORTH.	NORTH.

HOW TO FILL UP THE TABLE.—This Table may be filled up from the Deviation Table, in two ways; viz.:—Either by drawing the lines from all the points, half-points, and quarter-points in the *Correct Magnetic Course* Column, to such points, etc., in the *Standard Compass Course* Column that, on account of local attraction, correspond to the Correct Magnetic Course; or, *vice versâ*, by drawing lines from all the points, etc., in the *Standard Compass Course* Column to the correct courses in the *Correct Magnetic Course* Column. By many it will be preferred to the ordinary deviation table,* especially for deck use in squadrons performing steam evolutions. It shows at a glance the Standard Compass to be steered corresponding to the Correct Magnetic Course required, and *vice versâ*.

The first method will be the most useful to the Officers of the Watches in Tactical Manœuvres, and has been adopted in the Example. The second method will be useful in correcting Standard Compass Courses.

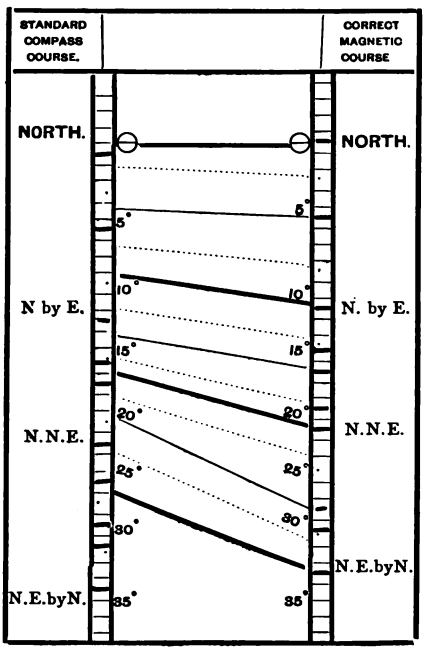
EXPLANATION.

HOW TO USE THE TABLE.

If the fleet is steering a given course by signal (which always means a correct magnetic course), and a signal is made to alter course a given number of points to Starboard or to port, run the finger up or down on the correct Magnetic Course Column the required number of points, and then across on the straight line to the Standard Compass Course Column; and the Standard Compass Course to be steered will be found.

* *See* page 55.

EXAMPLE.



The following are convenient Forms for Registering the Observations for Determining the Deviation of the Standard Compass.

Form for Registering the Process by Direct Bearing.

Ship's Head by the Standard Compass.	Bearing of..... by the Standard Compass.	Deviation of the Standard Compass.

Form for Registering the Process by Reciprocal Bearings.

Time.	Ship's Head by the Standard Compass.	Simultaneous Bearings.		Deviation of the Standard Compass.
		From Standard Compass on board.	From the Shore Compass.	

Table for converting Points of the Compass, and their Fractional Parts, into Degrees, etc.

POINTS.	No.	DEGREES, etc.	No.	POINTS.
		° ′ ″		
NORTH.	0	0 0 0	0	SOUTH.
	– ¼	1 24 22	– ¼	
	¼ –	2 48 45	¼	
	– ⅜	4 13 7	– ⅜	
N. ¼ E.....N. ¼ W.	¼ –	5 37 30	¼	S. ¼ W.....S. ¼ E.
	– ⅝	7 1 52	– ⅝	
	⅝ –	8 26 15	⅝	
	– ¾	9 50 37	– ¾	
N. by E.....N. by W.	1	11 15 0	1	S. by W.....S. by E.
	– ¼	12 39 22	– ¼	
	¼ –	14 3 45	¼	
	– ⅜	15 28 7	– ⅜	
N. by E. ¼ E...N. by W. ¼ W.	¼ –	16 52 30	¼	S. by W. ¼ W...S. by E. ¼ E.
	– ⅝	18 16 52	– ⅝	
	⅝ –	19 41 15	⅝	
	– ¾	21 5 37	– ¾	
N.N.E.....N.N.W.	2	22 30 0	2	S.S.W.....S.S.E.
	– ¼	23 54 22	– ¼	
	¼ –	25 18 45	¼	
	– ⅜	26 43 7	– ⅜	
N.N.E. ¼ E.....N.N.W. ¼ W.	¼ –	28 7 30	¼	S.S.W. ¼ W.....S.S.E. ¼ E.
	– ⅝	29 31 52	– ⅝	
	⅝ –	30 56 15	⅝	
	– ¾	32 20 37	– ¾	
N.E. by N.....N.W. by N.	3	33 45 0	3	S.W. by S.....S.E. by S.
	– ¼	35 9 22	– ¼	
	¼ –	36 33 45	¼	
	– ⅜	37 58 7	– ⅜	
N.E. ¼ N.....N.W. ¼ N.	¼ –	39 22 30	¼	S.W. ¼ S.....S.E. ¼ S.
	– ⅝	40 46 52	– ⅝	
	⅝ –	42 11 15	⅝	
	– ¾	43 35 37	– ¾	

Converting Points of the Compass into Degrees.
(Continued.)

POINTS.	No.	DEGREES, etc.	No.	POINTS.
		° ′ ″		
N.E.....N.W.	4	45 0 0	4	S.W.....S.E.
	¼	46 24 22	– ¼	
	¼ –	47 48 45	¼	
	¼	49 13 7	– ¼	
N.E. ¼ E.....N.W. ¼ W.	¼ –	50 37 30	¼	S.W. ¼ W..... .....S.E. ¼ E.
	¼	52 1 52	– ¼	
	¼ –	53 26 15	¼	
	¼	54 50 37	– ¼	
N.E. by E.....N.W. by W.	5	56 15 0	5	S.W. by W.....S.E. by E.
	¼	57 39 22	– ¼	
	¼ –	59 3 45	¼	
	¼	60 28 7	– ¼	
N.E. by E. ¼ E..... } N.W. by W. ¼ W..... }	¼ –	61 52 30	¼	{ S.W. by W. ¼ W..... { S.E. by E. ¼ E.
	¼	63 16 52	– ¼	
	¼ –	64 41 15	¼	
	¼	66 5 37	– ¼	
E.N.E.....W.N.W.	6	67 30 0	6	W.S.W.....E.S.E.
	¼	68 54 22	– ¼	
	¼ –	70 18 45	¼	
	¼	71 43 7	– ¼	
E. by N. ¼ N...W. by N. ¼ N.	¼ –	73 7 30	¼	W. by S. ¼ S...E. by S. ¼ S.
	¼	74 31 52	– ¼	
	¼ –	75 56 15	¼	
	¼	77 20 37	– ¼	
E. by N.....W. by N.	7	78 45 0	7	W. by S.....E. by S.
	¼	80 9 22	– ¼	
	¼ –	81 33 45	¼	
	¼	82 58 7	– ¼	
E. ¼ N.....W. ¼ N	¼ –	84 22 30	¼	W. ¼ S..... .....E. ¼ S.
	¼	85 46 52	– ¼	
	¼ –	87 11 15	¼	
	¼	88 35 37	– ¼	
EAST.....WEST,	8	90 0 0	8	WEST .....EAST.

To Correct the Compass for Variation.

Course by Compass given.	*True Course given.*
If Variation East, allow to right.	If Variation East, allow to left,
If Variation West, allow to left.	If Variation West, allow to right.
Will give true course.	Will give magnetic course.

To Correct the Compass Courses.

Easterly Variation is + to all points between N. and E.....S. and W.
Westerly Variation is — from all points between N. and E...S. and W.
Easterly Variation is — from all points between N. and W...S. and E.
Westerly Variation is + to all points between N. and W.....S. and E.

To Convert a True Course into a Compass Course.

Easterly Variation is — from all points between N. and E....S. and W.
Westerly Variation is + to all points between N. and E.....S. and W.
Easterly Variation is + to all points between N. and W.....S. and E.
Westerly Variation is — from all points between N. and W...S. and E.

To Correct the Course at once for Variation and Deviation.

If they are both of the same name, *i.e.* both E. or both W., add one to the other, and apply the sum according to their joint name. *Example:*—Compass course N.N.E.; given, the deviation 8° 10′ E., and the variation 20° 10′ E., the sum thereof 28° 20′ E., being applied to the *right* hand of N.N.E., gives the true course, N. 50° 50′ E. But if one be E. and the other W., take their difference, give it the name of the greater, and apply it according to that name. *Example*:—Suppose the deviation be still 8° 10′ E., but with the variation of 20° 10′ W., their difference 12° 0′ West, applied to the left hand, will give N. 10° 30′ E. for the true course.

SIR WILLIAM THOMSON'S COMPASS.

THE following description of this Compass, which is now largely in use in the Mercantile Marine, and is also supplied to H.M. ironclad ships, is taken from a paper read by the inventor at the United Service Institution.

To produce such steadiness of the compass-card as has hitherto been obtained in steamers which have powerful engines, and where there is much vibration, it has been customary to suspend the bowl by means of india-rubber bands. A serious objection to this method is that the india-rubber is liable to become rotten by exposure to heat or oil, especially if it is used in fine enough bands to give the requisite steadiness in all circumstances. After many trials of metallic springs in lieu of the india-rubber, I at last found a plan of brass spring resembling a rope grummet (A, Figs. 1, 2, 3, 4. 5, 6), but with elastic brass wire instead of the rope strands, by which I succeeded in obtaining more satisfactory steadiness of the compass than with india-rubber. The construction of this brass grummet-ring and the mounting of the compass bowl upon it, may be described as follows:—A single wire is first bent and its ends are united by soldering or brazing, so as to form a ring of the proper size. This serves as a core on which a second brass wire is laid spirally, six turns round the core (Fig. 6). The ends of this second wire are also united by soldering or brazing, and thus an elastic ring is produced strong enough to support the compass bowl. The compass bowl is suspended from the elastic ring with the intervention of a rigid gimbal ring. The elastic ring has two sockets fixed at the ends of a diameter, which rest on two balls attached to the brass rim of the binnacle stand (Figs. 3 and 4). The elasticity of the ring mitigates the effect on the knife edges bearing the gimbal ring and bowl, and on the point bearing the compass card, of vertical tremors of the platform on which the binnacle rests. The knife edges of the gimbal ring are supported on two grooved stirrups, hung by chains from the elastic rings (Figs. 5 and 6). This suspension mitigates the effect of horizontal tremors of the platform.

Figs. 1, 2, 3, 4, 5, 6 illustrate the suspension of the bowl from the elastic ring.

For ascertaining the heeling error I use an auxiliary instrument for comparing the vertical component of the earth's magnetic force on shore with the vertical component on board ship. This instrument is constructed as follows:—Two magnetic needles of hardened steel wire are joined together and supported on two iridium points in a line at right angles to the lengths of

the needles, and passing as nearly as may be through the centre of gravity of the needles and frame. One of these points rests on a flat support of sapphire or other suitable hard material, and the other point rests in a cylindrically shaped support of similar hard material.

The needles are accurately balanced so as to be horizontal when resting on the points before being magnetized, and they are then magnetized. The needles are brought to a level position again by a vertical magnet placed at equal distances from the four poles of the needles, and capable of being moved up and down. The position of the vertical magnet, according as it is higher or lower, gives a greater or less vertical force on the needles, the amounts of this force being determined by experiment for different positions of the vertical magnet.

This dipping-needles instrument is shown in Figs. 7 and 8; *i i* are the magnetic needles connected together by the framework, *j j*, and supported on the tops of the columns by two iridium points, *k k*.

When the instrument is used in the binnacle the compass bowl is taken out and the instrument is put in its place. The instrument is supported by cords from the elastic ring of the compass, which can be lengthened or shortened to adjust the instrument to the level and to the proper height, to bring the needles to the same position as the needles of the compass card, when the bowl is in its place.

The binnacle, with the arrangement of correctors for correcting the semicircular, quadrantal, and heeling errors, is shown in Figs. 9, 10, and 11. M M are the receptacles for the fore and aft magnets; M^1 M^1 are the receptacles for the thwartship magnets; and H is the Flinders bar. In Fig. 10 the dipping-needles instrument is shown hanging in its place in the binnacle.

The binnacle contains mechanical appliances for realizing in practice the principles of correction discovered and published originally by Captain Flinders and Sir George Airy. The correctors for the several parts of the compass error are as follows:—

To correct the "quadrantal error," a pair of unmagnetic iron globes (solid or hollow), fixed on each side of the binnacle.

To correct the "semicircular error," bar-magnets in symmetrically placed long horizontal holes thwartships and fore-and-aft within the binnacle, and a Flinders bar (described below) attached to the binnacle outside on the fore or aft side.

To correct the "heeling error," three, two, or one bar-magnets in a brass can hung by a chain, by which it can be moved up and down and secured in

any position in a brass tube fixed in the centre of the binnacle, under the compass bowl.

The part of the heeling error which depends on magnetism transiently induced by the vertical components of the earth's magnetic force, is always partially and may be wholly corrected by the globes and the Flinders bar. The heeling error on the east and west courses is wholly corrected by the Flinders bar.

The corrector-magnets regularly provided with the binnacle for the 10-inch compass are round bars of glass-hard steel, 9 inches long and ·4 of an inch or ·2 of an inch diameter. Each magnet is painted blue in one half of its length, and red in the other half, according to a happy suggestion of Sir George Airy's; blue to mark the end possessing the same kind of magnetism as the earth's north polar regions, and red to mark the end possessing the same kind of magnetism as the earth's south polar regions.*

The fore-and-aft corrector-holes (shown at M M, Figs. 9 and 11) are in two vertical rows or scales, at equal distances of about five inches from the middle of the binnacle. The thwartship corrector-holes are in one vertical row (shown at M′ M′, Figs. 10 and 11), about the same distance forward or aft from the centre of the binnacle. The holes in each vertical scale are spaced to give equal augmentations or diminutions of corrective force, when one of the corrector-magnets is shifted up or down from hole to hole in order. They are marked with numbers proportional to the corrective forces.

One of the corrector-magnets, when held horizontally with its two ends equi-distant from the centre of the compass, exerts forces on the ends of the needles in lines parallel to its own length, and in opposite directions on the two ends of each needle. These forces, transmitted through the silk bearing threads, pull the north point of the card towards the side on which the blue end of the corrector is held. Hence a pull† to port or to starboard is produced by a magnet in one of the thwartship corrector-holes, with blue end to port or to starboard: and a pull forward or aft, by a magnet in one of the fore-and-aft corrector-holes, with its blue end forward or aft. With magnets already in some of the corrector-holes, if a pull to port is wanted, it

* The blue ends are properly called "true north poles," and the red "true south poles," but (because of the law that likes repel, and unlikes attract, in magnetism) the true north pole points south, and the true south pole north, if a bar magnet is hung horizontally by a thin thread, and therefore English instrument makers (still unmoved by Gilbert's protest 280 years ago) mark the true north poles S, and the true south poles N. All ambiguity is removed in a particularly convenient manner by the Astronomer Royal's blue and red marking.

† A pull to port or to starboard, or a pull forward or a pull aft, is a short expression for a magnetic force pulling the north points of the compass card to port, or to starboard, or forward, or aft.

Fig 1

RECENT IMPROVEMENTS IN THE COMPASS.

by Sir William Thomson, LL.D.

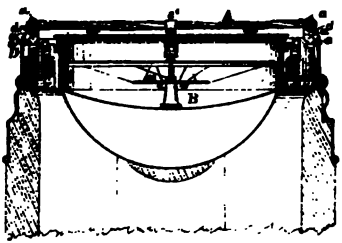


Fig 2

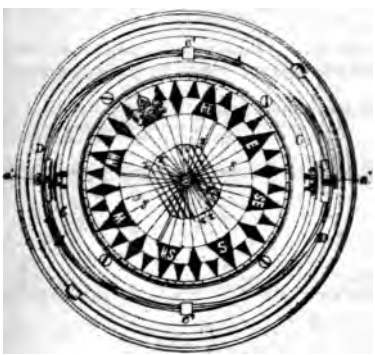


Fig 3

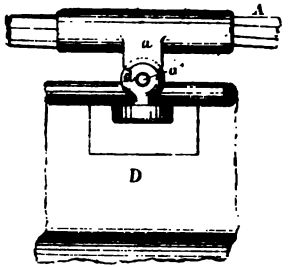


Fig 5

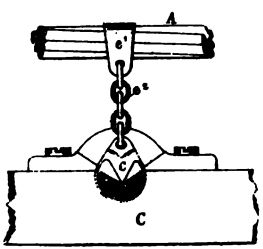


Fig 6.

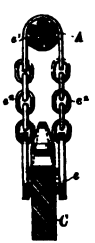


Fig 9

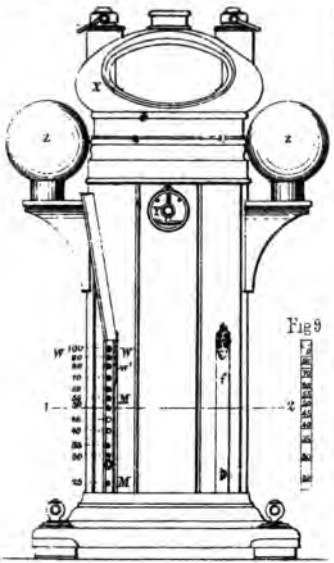
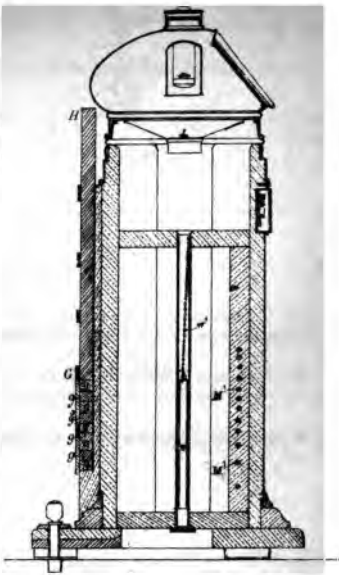


Fig 10.



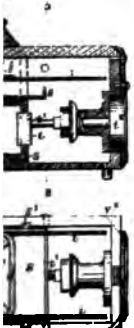
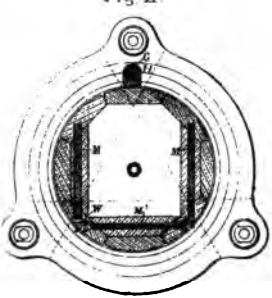


Fig 11



is had by raising one of the bars in the thwartship scale, if its blue end is to port, or lowering or removing or reversing it if its blue end is to starboard; and if a pull forward is wanted, it is had by raising a magnet in one of the fore-and-aft scales, if its blue end is forward, or lowering or removing or reversing it if its blue end is aft.

Westerly error * when the ship's head is north, or easterly error when the ship's head is south, is to be corrected by a pull to starboard.

Easterly error when the ship's head is north, or westerly error when the ship's head is south, is to be corrected by a pull to port.

Easterly error when the ship's head is east, or westerly error when the ship's head is west, is to be corrected by a pull aft.

Westerly error when the ship's head is east, or easterly error when the ship's head is west, is to be corrected by a pull forward.

When the globes for correcting the quadrantal error have been once properly placed, no change of this adjustment is ever necessary for the same ship, and the same position of the compass in it, except in the case of some change in the ship's iron, or iron cargo, or ballast, sufficiently near the compass to sensibly alter the quadrantal error. But the magnetic correctors for the semicircular error and the heeling error must be adjusted from time to time, to keep the compass correct.

The Flinders bar supplied with the compass is a round bar of soft iron, 3 inches in diameter, and of whatever length of from 6 inches to 24 inches is found to be proper for the actual position of the compass in any particular ship. To make up the proper length it is supplied in pieces of 12 inches, 6 inches, 3 inches, 1½ inches, and two pieces of ¾ of an inch. In making up the proper length the longest piece should be uppermost and the others below it in order of their lengths. The weight of the bar is supported on a wooden column or bar, resting on a pedestal fixed to the binnacle near its foot, this wooden bar being cut to such a length, or so made up of pieces, as to give the proper height to the upper end of the iron bar. The compound column of iron and wood is kept in position and protected from rain and spray by a brass tube, with upper end closed, going down over it.

The main object of the Flinders bar is to counterbalance the component of the ship's horizontal force on the compass, which is due to magnetism induced by the vertical component of the terrestrial magnetic force. Hence, in all ordinary cases, the ship's iron being symmetrical on the two sides of

* The error is called easterly, when the north point of the compass card is on the east side of the correct magnetic north and south line; westerly, when on the west side of this line.

the fore-and-aft midship vertical plane, and the compass being placed on this plane, the Flinders bar must be placed in it also, and therefore must be exactly in the middle of the front side, or of the after side of the binnacle. The Flinders bar essentially corrects, wholly and permanently, the constituent of the heeling error, which has its maximum values on the east and west courses. A subordinate object of the Flinders bar, as supplied to my compass, is to partially correct the constituent of the heeling error, which has equal maximum values on the north and south courses, by partially counterbalancing the component force on the compass, perpendicular to the ship's deck, exerted by that part of the ship's magnetism which is induced by the vertical component of the earth's magnetic force. For this object also the proper position of the bar is up and down in the middle of the forward or after side of the binnacle; but for it the bar should be lowered a little below, or raised a little above, the position in which, without altering the length of the bar, it gives its maximum horizontal force on the compass. When it is not desired to make this contribution to the heeling correction by the Flinders bar, it should be placed with its top about two inches above the level of the needles of the compass card.

To understand the action of the Flinders bar, suppose first the ship to be anywhere in the northern magnetic hemisphere.* The vertical force there is such as to pull the red end or pole of a magnetized needle downwards, and to repel the blue end upwards. It also has the effect of inducing magnetism in any mass of iron, so as to give it a transient magnetic quality marked with blue in the upper side or end and red on the lower side or end. Thus, on the northern magnetic hemisphere the Flinders bar is transiently magnetized by the earth's vertical force in such manner that it acts like a great bar-magnet with its upper end blue and its lower end red. At the magnetic equator it loses its magnetism, and in the southern magnetic hemisphere it acquires magnetism in the opposite direction to that which it had in the northern hemisphere; so that now its upper end is red and its lower end blue. As the ship moves from one hemisphere across the magnetic

* The earth's surface is divided into two parts, called the northern and southern magnetic hemispheres, by a line called the magnetic equator, which is the line of no dip. This line is not a great circle like the true equator, but a sinuous line north of the true equator in all east longitude, and from 180° to 173° of west longitude; and south of the equator in all west longitude less than 173°. Its greatest distance on either side of the equator is where it cuts the coast of Brazil in about 17° south latitude. Its greatest distance north of the equator is in the Indian Ocean, which it crosses from Africa, a little south of Cape Guardafui, to the south of India, very nearly along the tenth parallel of north latitude, and eastward across the mouth of the Bay of Bengal to the Malay Peninsula, still but little short of this degree of north latitude. A chart of the lines of equal magnetic dip, such as the very convenient small one of the Admiralty Compass Manual, should be carefully studied.

equator to the other, the magnetism of the Flinders bar gradually* diminishes to zero, and then increases gradually in the contrary direction. The object to be attained in applying it to the binnacle is that, with this gradual change of its magnetism, it shall always as exactly as possible counterbalance the changing part of the force on the compass, due to the part of the ship's magnetization which changes with the gradual change of the vertical component of the terrestrial magnetic force. If this changing part of the ship's disturbing force on the compass is a pull aft in the northern magnetic hemisphere, and a pull forward in the southern magnetic hemisphere, the Flinders bar must be on the forward side of the binnacle. On the other hand, if the regularly changing part of the ship's force be a pull forward in the northern hemisphere, and aft in the southern hemisphere, the Flinders bar must be on the after side of the binnacle. The former is the most frequent case for the chief navigating standard compass and for the steering compass of modern mail steamers and merchant steamers generally, in which the steering and conning of the ship is done on a bridge forward of the engines, with considerably more than half of the ship behind it. It is also almost certain to be the case for an after-steering compass, a few feet in advance of the top of the iron stern-post and rudder-head, in an iron steamer or sailing ship. The second above-mentioned case is what will generally be found for a compass anywhere in the after half of the ship's length, to within two or three yards of the stern-post. Most frequently it is not possible to ascertain which of the two is the actual case until the ship has made a voyage through regions presenting considerable differences of vertical magnetic force. The best plan generally is, in first placing the binnacle on the deck, to turn it with the fittings of the Flinders bar forward or aft, according as it is found that the fore-and-aft correcting magnets have to be placed with red or blue poles forward or aft. It may be that the experience of a first voyage may show that the binnacle must be turned the other way to get the Flinders bar into its right position; but the chance of this being necessary is less if the binnacle is first placed according to the preceding rule, than if it is placed in the opposite direction without some knowledge to guide. If it has to be turned, the turning is done in a few minutes, for any binnacle made after January, 1880, as the binnacle has four feet, which are screwed by brass bolts to brass sockets fixed in the deck, and fitting for either side of the binnacle foremost.

In the first adjustment, or as long as there is special knowledge as to the

* The change of polarity in vertical bars in the ship, which takes place in crossing the magnetic equator, has sometimes been falsely supposed to be abrupt, and mistakes in respect to compass courses have been made in consequence.

proper proportion of correction to be made by the Flinders bar, it may be set to correct about half of the whole error on the east and west courses; the remainder must be accurately corrected by the fore-and-aft magnets.

Suppose now the first adjustment to have been made somewhere in the northern magnetic hemisphere, and suppose that as the ship goes to places of weaker vertical force* the fore-and-aft correcting force required to make the compass correct on the east or west points is found to be less than at the beginning of the voyage. It is clear that part of the correction made by the magnets ought to have been made by the Flinders bar. But nothing need be done except to diminish the fore-and-aft pull by the magnets, as long as the ship is going to places of weaker vertical force. If without touching or crossing the magnetic equator the ship returns again to places of stronger vertical force, and if it is found that increased longitudinal pull is now required, this should be applied, not by the magnets, but by introducing a Flinders bar or by increasing the bar already in position.

Generally, for a ship making passages to and fro through regions of considerably different vertical force, whether she crosses the magnetic equator or not, the rule in respect of the fore-and-aft correction is as follows:—

Correct the deviations found by observation on the east or west courses by the fore-and-aft magnets when the ship is going to places of weaker, and by the Flinders bar when she is going to places of stronger, vertical force, whether in the southern or northern hemisphere.

After a few voyages the proper proportion of correction by Flinders bar to correction by bar-magnets will be practically realized.

* "Vertical force" is a short expression for the vertical component of the earth's magnetic force. It is reckoned as positive when the direction of its action upon a red pole is downwards, as in the northern hemisphere; and negative when upwards, as in the southern hemisphere. At the magnetic equator it is zero. The amount of the vertical force at any place is calculated by multiplying the value of the horizontal force given by the chart of lines of equal horizontal force of the Admiralty Manual by the tangent of the dip as given by the chart of lines of equal magnetic dip. Thus, for example, the tangent of the dip for the south of England being 2·44, and the horizontal force there being called unity, the vertical force there is 2·44. The tangent of the dip at Aden is ·09, and the horizontal force there is 1·95; hence the vertical force there is ·1755, or about $\frac{1}{6}$ of the vertical force at the south of England.

SECTION III.

RULE OF THE ROAD AT SEA—PRACTICAL RULES—LOCAL REGULATIONS—MERCHANT SHIPPING ACT RELATING TO COLLISIONS.

REGULATIONS FOR PREVENTING COLLISIONS AT SEA.

Preliminary.

ART. 1. In the following rules every steamship which is under sail and not under steam is to be considered a sailing ship; and every steamship which is under steam, whether under sail or not, is to be considered a ship under steam.

Rules concerning Lights.

Art. 2. The lights mentioned in the following Articles, numbered 3, 4, 5, 6, 7, 8, 9, 10, and 11, and no others, shall be carried in all weathers, from sunset to sunrise.

Art. 3. A sea-going steamship when under way shall carry—

(*a*) On or in front of the foremast, at a height above the hull of not less than 20 feet, and if the breadth of the ship exceeds 20 feet then at a height above the hull not less than such breadth, a bright white light, so constructed as to show an uniform and unbroken light over an arc of the horizon of 20 points of the compass; so fixed as to throw the light 10 points on each side of the ship, viz. from right ahead to two points abaft the beam on either side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least five miles.

(*b*) On the starboard side, a green light so constructed as to show an uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(*c*) On the port side, a red light, so constructed as to show an uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the port side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(*d*) The said green and red side-lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Art. 4. A steamship, when towing another ship, shall, in addition to her side-lights, carry two bright white lights in a vertical line one over the other, not less than three feet apart, so as to distinguish her from other steamships. Each of these lights shall be of the same construction and character, and

shall be carried in the same position, as the white light which other steamships are required to carry.

Art. 5. (*a*) A ship, whether a steamship or a sailing ship, which from any accident is not under command, shall at night carry, in the same position as the white light which steamships are required to carry, and, if a steamship, in place of that light, three red lights in globular lanterns, each not less than 10 inches in diameter, in a vertical line one over the other, not less than *three* feet apart: and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles; and shall by day carry in a vertical line one over the other, not less than *three* feet apart, in front of but not lower than her foremast-head, three black balls or shapes, each two feet in diameter.

(*b*) A ship, whether a steamship or a sailing ship, employed in laying or in picking up a telegraph cable, shall at night carry in the same position as the white light which steamships are required to carry, and, if a steamship, in place of that light, three lights in globular lanterns, each not less than 10 inches in diameter, in a vertical line over one another, not less than *six* feet apart; the highest and lowest of these lights shall be *red*, and the middle light shall be *white*, and they shall be of such a character that the red lights shall be visible at the same distance as the white light. By day she shall carry in a vertical line one over the other not less than *six* feet apart, in front of but not lower than her foremast-head, three shapes not less than two feet in diameter, of which the top and bottom shall be globular in shape and *red* in colour, and the middle one diamond in shape and *white*.

(*c*) The ships referred to in this Article, when not making any way through the water, shall not carry the side lights, but when making way shall carry them.

(*d*) The lights and shapes required to be shown by this Article are to be taken by other ships as signals that the ship showing them is not under command, and cannot therefore get out of the way. The signals to be made by ships in distress and requiring assistance are contained in Article 27.

Art. 6. A sailing ship under way, or being towed, shall carry the same lights as are provided by Article 3 for a steamship under way, with the exception of the white light, which she shall never carry.

Art. 7. Whenever, as in the case of small vessels during bad weather, the green and red side-lights cannot be fixed, these lights shall be kept on deck, on their respective sides of the vessel, ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side.

To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the colour of the light they respectively contain, and shall be provided with proper screens.

Art. 8. A ship, whether a steamship or a sailing ship, when at anchor, shall carry, where it can best be seen, but at a height not exceeding 20 feet above the hull, a white light, in a globular lantern of not less than eight inches in diameter, and so constructed as to show a clear uniform and unbroken light, visible all round the horizon, at a distance of at least one mile.

Art. 9. A pilot vessel, when engaged on her station on pilotage duty, shall not carry the lights required for other vessels, but shall carry a white light at the masthead, visible all round the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

A pilot vessel, when not engaged on her station on pilotage duty, shall carry lights similar to those of other ships.

Art. 10. Open boats and fishing vessels of less than twenty tons net registered tonnage, when under way, and when not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the coloured side-lights; but every such boat shall in lieu thereof have ready at hand a lantern with a green glass on the one side and a red glass on the other side; and on approaching to or being approached by another vessel, such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

The following portion of this Article applies only to fishing vessels and boats when in the sea off the coast of Europe lying north of Cape Finisterre:—

(*a*) All fishing vessels and fishing boats of 20 tons net registered tonnage, or upwards, when under way and when not required by the following regulations in this Article to carry and show the lights therein named, shall carry and show the same lights as other vessels under way.

(*b*) All vessels when engaged in fishing with drift nets shall exhibit two white lights from any part of the vessel where they can be best seen. Such lights shall be placed so that the vertical distance between them shall be not less than *six* feet and not more than *ten* feet; and so that the horizontal distance between them measured in a line with the keel of the vessel shall not be less than *five* and not more than *ten* feet. The lower of these two lights shall be the more forward, and both of them shall be of such a character, and contained in lanterns of such construction as to show all round the horizon, on a dark night with a clear atmosphere, for a distance of not less than three miles.

(*c*) A vessel employed in line fishing, with her lines out, shall carry the same lights as a vessel when engaged in fishing with drift nets.

(*d*) If a vessel when fishing becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall show the light and make the fog signal for a vessel at anchor.

(*e*) Fishing vessels and open boats may at any time use a flare-up in addition to the lights which they are by this Article required to carry and show. All flare-up lights exhibited by a vessel when trawling, dredging, or fishing with any kind of drag net shall be shown at the

after part of the vessel, excepting that, if the vessel is hanging by the stern to her trawl, dredge, or drag net, they shall be exhibited from the bow.

(*f*) Every fishing vessel and every open boat when at anchor between sunset and sunrise shall exhibit a white light visible all round the horizon at a distance of at least one mile.

(*g*) In fog, mist, or falling snow, a drift-net vessel attached to her nets, and a vessel when trawling, dredging, or fishing with any kind of drag net, and a vessel employed in line fishing with her lines out, shall at intervals of not more than two minutes make a blast with her fog-horn and ring her bell alternately.

Art. 11. A ship which is being overtaken by another shall show from her stern to such last-mentioned ship a white light or a flare-up light.

Sound Signals for Fog, etc.

Art. 12. A steamship shall be provided with a steam whistle, or other efficient steam sound-signal, so placed that the sound may not be intercepted by any obstructions, and with an efficient fog-horn to be sounded by a bellows or other mechanical means, and also with an efficient bell.* A sailing ship shall be provided with a similar fog-horn and bell.

In fog, mist, or falling snow, whether by day or night, the signals described in this Article shall be as follows; that is to say—

(*a*) A steamship under way shall make with her steam whistle, or other steam sound signal, at intervals of not more than two minutes, a prolonged blast.

(*b*) A sailing ship under way shall make with her fog-horn, at intervals of not more than two minutes, when on the starboard tack one blast, when on the port tack two blasts in succession, and when with the wind abaft the beam three blasts in succession.

(*c*) A steamship and a sailing ship, when not under way, shall, at intervals of not more than two minutes, ring the bell.

Art. 13. Every ship, whether a sailing ship or steamship, shall, in a fog, mist, or falling snow, go at a moderate speed.

Steering and Sailing Rules.

Art. 14. When two sailing ships are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, viz.:—

(*a*) A ship which is running free shall keep out of the way of a ship which is close-hauled.

(*b*) A ship which is close-hauled on the port tack shall keep out of the way of a ship which is close-hauled on the starboard tack.

* In all cases where the regulations require a bell to be used, a drum will be substituted on board Turkish vessels.

(*c*) When both are running free with the wind on different sides, the ship which has the wind on the port side shall keep out of the way of the other.

(*d*) When both are running free with the wind on the same side, the ship which is to windward shall keep out of the way of the ship which is to leeward.

(*e*) A ship which has the wind aft shall keep out of the way of the other ship.

Art. 15. If two ships under steam are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This Article only applies to cases where ships are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two ships which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are, when each of the two ships is end on, or nearly end on, to the other; in other words, to cases in which, by day, each ship sees the masts of the other in a line, or nearly in a line, with her own; and by night, to cases in which each ship is in such a position as to see both the side-lights of the other.

It does not apply by day, to cases in which a ship sees another ahead crossing her own course; or by night, to cases where the red light of one ship is opposed to the red light of the other, or where the green light of one ship is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

Art. 16. If two ships under steam are crossing, so as to involve risk of collision, the ship which has the other on her own starboard side shall keep out of the way of the other.

Art. 17. If two ships, one of which is a sailing ship, and the other a steamship, are proceeding in such directions as to involve risk of collision, the steamship shall keep out of the way of the sailing ship.

Art. 18. Every steamship, when approaching another ship, so as to involve risk of collision, shall slacken her speed or stop and reverse, if necessary.

Art. 19. In taking any course authorized or acquired by these Regulations, a steamship under way may indicate that course to any other ship which she has in sight by the following signals on her steam whistle, viz.:—

One short blast to mean "I am directing my course to starboard."

Two short blasts to mean "I am directing my course to port."

Three short blasts to mean "I am going full speed astern."

The use of these signals is optional; but if they are used, the course of the ship must be in accordance with the signal made.

Art. 20. Notwithstanding anything contained in any preceding Article, every ship, whether a sailing ship or a steamship, overtaking any other shall keep out of the way of the overtaken ship.

Art. 21. In narrow channels every steamship shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such ship.

Art. 22. Where by the above rules one of two ships is to keep out of the way, the other shall keep her course.

Art. 23. In obeying and construing these rules due regard shall be had to all dangers of navigation; and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

No Ship, under any Circumstances, to neglect Proper Precautions.

Art. 24. Nothing in these rules shall exonerate any ship, or the owner, or master, or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper look-out, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Reservation of Rules for Harbours and Inland Navigation.

Art. 25. Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbour, river, or inland navigation.

Special Lights for Squadrons and Convoys.

Art. 26. Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal lights for two or more ships of war or for ships sailing under convoy.

Summary of Lights ordered to be carried when under Way.

Sailing ship	Green Light starboard side. Red Light port side.
Steamship	Green Light starboard side. Red Light port side. White Light before foremast, not less than twenty feet, nor less than breadth of ship, above hull.
Ship being overtaken by another ship	White Light or flare-up light at stern.
Steamer towing another ship	Green Light starboard side. Red Light port side. Two White Lights vertically before foremast.
Sailing ship being towed	The same as other sailing ships.
Ship laying or picking up a telegraph cable	Three vertical Lights before foremast, six feet apart, the highest and lowest Red, the middle White. By day, *see* Art. 5 (*b*).
Ship not under command	Three vertical Red Lights before foremast, three feet apart. By day, *see* Art. 5 (*a*).
Pilot vessel on pilotage duties	White Light at masthead, and at intervals not exceeding fifteen minutes a flare-up light.
Pilot vessel, when not on pilotage duties	The same lights as other ships.
Open fishing and other open boats	In lieu of side-lights, a lantern showing Green on one side and Red on the other, to be exhibited in sufficient time to prevent a collision. They may also use a flare-up in addition. *See* Art. 10.
Fishing vessels employed in drift-net fishing, or trawling.	Two White Lights from any part of the vessel where they can be best seen. Lower light to be forward, not less than *six* nor more than *ten* feet from the higher light. They may also use a flare-up in addition. All flare-up lights exhibited when trawling, dredging, or fishing, shall be shown from the after part of the vessel, excepting that, if the vessel is hanging by the stern to her trawl, dredge, or net, they shall be exhibited from the bow. *See* Art. 10, *b* and *c*.

Light ordered to be carried at Anchor.

All ships, vessels, boats, and fishing vessels—A bright White Light.

If a fishing vessel becomes stationary in consequence of her net fouling a rock or other obstruction, she shall show the light and make the fog signal for a vessel at anchor.

Fog Signals.

Fog signals ordered to be sounded at intervals of not more than *two* minutes when there is a fog, mist, or falling snow.

Steamship under way—A prolonged blast with steam whistle.

Sailing ship under way—Blasts with a fog-horn, viz.:—On starboard tack, one blast. On port tack, two blasts in succession. With wind abaft the beam, three blasts in succession.

Fishing vessel fishing—Blast with a fog-horn, and ring a bell alternately.

All Ships at anchor—Ring a bell. *Turkish vessels:* Beat a drum.

NOTE 1.—Article 12 prescribes that the fog-horn shall be "sounded by a bellows or other mechanical means."

NOTE 2.—Article 13 directs that every ship, whether a sailing ship or steamship, shall, in a fog, mist, or falling snow, go at a moderate speed.

Observations on the Rules.

By far the greater number of collisions are undoubtedly caused by bad look-out, by ignorance of the regulations, or by neglect of them.

Under the heads of ignorance and neglect may be included the frequent practice of altering course prematurely, without having first ascertained *which way* it should be altered, and also of deviating from your course when it is your duty to keep it.

There are nine cases in which a ship is required to alter course to avoid risk of collision.

1. In a steamship meeting another steamship end on, or nearly end on.
2. In a steamship nearing another on her own starboard side.
3. In a steamship nearing a sailing ship.
4. In a steam or sailing ship overtaking another.
5. In a sailing ship running free nearing a ship close-hauled.
6. In a sailing ship close-hauled on the port tack nearing another close-hauled on the starboard tack.

7. In a sailing ship running free with the wind on the port side nearing another running free with the wind on the starboard side.

8. In a sailing ship running free nearing another to leeward also running free with the wind on the same side.

9. In a sailing ship with the wind aft nearing another sailing ship.

In the *first* case *only* is no option allowed as to the course to be pursued. The directions are quite distinct, you are to "*alter course to starboard:*" in all the other cases you are to "*keep out of the way.*"

In the ship giving way, having determined *which way* to alter course to avoid a collision, do so in *good time.* Do not let the people in the other ship imagine that they are not seen, or that the situation is misunderstood, and so perhaps tempt them to do something which may bring about a collision. If in the ship holding on, you must be especially careful not to yaw about or steer wildly, but let the giving-way ship see that you know your duty is to keep on your course, and that you intend to do so.

So long as you keep a Green Light opposed to a Green Light, or a Red Light opposed to a Red Light, no collision can happen between passing ships.

The reckless use of Port Helm leads to collision.

Vice-Admiral de Horsey, in his small book on the "Rule of the Road," gives Practical Rules drawn up in accordance with the "Regulations for preventing Collisions at Sea," which are so clear that they have been reprinted here. He says "the whole principle of keeping clear of the other vessel consists in taking two bearings, with an interval between them, to ascertain whether you are, or are not, converging to the same point."

It may be said "whilst you are taking your two bearings, with an interval between them, the ships may approach so near as to risk collision." But the reply to this is that, firstly, vessels' lights can be seen at least two miles off in clear weather, and that in thick weather no rules will avail, except such as make slow speed compulsory; and, secondly, that if the plan of taking two bearings will not answer, no other plan will; for it is the only practicable method of ascertaining whether, and which way, to alter course.

"Taking the bearing" has been advocated here because it is the most accurate way, and is not affected by any momentary bad steerage; but it is unnecessary to explain to practical seamen that, provided a vessel is steered on a steady course, the more ready method of bringing the other vessel *on with* some part of the rigging or bulwark, and observing whether she draws aft or forward, will equally answer the purpose.

UNDER SAIL ONLY.

Close-Hauled—On Starboard Tack.

DIRECTIONS ON NEARING A VESSEL.

Keep your course, but do not steer wildly, lest you should deceive the ship whose duty it is keep clear of you.

Close-Hauled—On Port Tack.

DIRECTIONS ON NEARING A VESSEL.

1st. Take bearing.
2nd. Ascertain whether a Steamer or not.
3rd. If a Steamer, keep your course.
4th. If a Sailing Vessel—
(*a*) If to windward of you, keep your course.
(*b*) If ahead of you, or less than two or three points on lee bow, keep your course.
(*c*) If to leeward of you, or more than two or three points on lee bow—
1. Take bearing again.
2. If her bearing has altered materially, and continues so to alter, keep your course.
3. If her bearing has not altered materially, tack, or bear away until it does so.

Wind Aft.

DIRECTIONS ON NEARING A VESSEL.

1st. Take bearing.
2nd. Ascertain whether a Steamer or not.
3rd. If a Steamer, keep your course.
4th. If a Sailing Vessel—
(*a*) If right astern, or if overtaking you, keep your course.
(*b*) If in any other direction (except right astern, or overtaking you)—
1. Take bearing again.
2. If her bearing has altered materially, and continues so to alter, keep your course.
3. If her bearing has not altered materially, alter course sufficiently to starboard or port to assist to alter her bearing.

Running Free—Wind on Starboard Side.

DIRECTIONS ON NEARING A VESSEL.

1st. Take bearing.
2nd. Ascertain whether a Steamer or not.
3rd. If a Steamer, keep your course.
4th. If a Sailing Vessel—
(*a*) If to windward of you, or if ahead of you and going free, or if her Red Light only (or her port side) shows, *provided always she is not close-hauled*, keep your course.
(*b*) If ahead of you and close-hauled, or if to leeward of you, or if her Green Light only (or her starboard side) shows, or if you are overtaking her—
1. Take bearing again.
2. If her bearing has altered materially, and continues so to alter, keep your course.
3. If her bearing has not altered materially, alter course sufficiently to starboard or port to assist to alter her bearing.

Running Free—Wind on Port Side.

DIRECTIONS ON NEARING A VESSEL.

1st. Take bearing.
2nd. Ascertain whether a Steamer or not.
3rd. If a Steamer, keep your course.
4th. If a Sailing Vessel *—
(*a*) If to windward of you, and with the wind on her port side, or right aft, keep your course.
(*b*) Under all other circumstances—
1. Take bearing again.
2. If her bearing has altered materially, and continues so to alter, keep your course.
(*c*) If she is on your starboard side—
1. Take bearing again.
2. If she has altered her bearing materially, keep your course.
3. If her bearing has not altered materially, alter course sufficiently to starboard or port to assist to alter her bearing.

* This is a case of doubt and danger if you cannot tell on which side the approaching ship has the wind.

UNDER STEAM.

Directions on nearing a Vessel.

If the approaching Vessel (whether she be a Steamer or a Sailing Ship) shows her starboard side, or Green Light only, *to your starboard side, or Green Light*—or if she shows her port side, or Red Light only, *to your port side, or Red Light*, keep your course; but otherwise—

1st. Take bearing.

2nd. Ascertain whether a Steamer or not.

3rd. If a Steamer—
- (*a*) If she is on your port side, keep your course.
- (*b*) If she is ahead—
  1. If her Green and mast-head Lights only (or her starboard side) show, keep your course.
  2. If the Red and mast-head Lights only (or her port side) show, keep your course.
  3. If her Green and Red Lights both show (or if she is end on or nearly end on), port your helm and alter course to starboard until you shut out her Green Light or starboard side.

4th. If a Sailing Vessel—
- (*a*) If she is ahead—
  1. If only one side light shows (*i.e.* if not end on, nor nearly end on), keep your course.
  2. If her Green and Red Lights both show, or if she is end on or nearly end on, alter course to starboard or port sufficiently to shut out one of her side lights.
- (*b*) If she is not ahead—
  1. Take bearing again.
  2. If she has altered her bearing materially, keep your course.
  3. If her bearing has not altered materially, alter course sufficiently to starboard or port to assist to alter her bearing.

Note 1.—Whether it be your duty or not to alter course, observe Article 18 of the Regulations, which is as follows:—"Every Steamship, when approaching another Ship so as to involve Risk of Collision, shall slacken her speed, or, stop and reverse, if necessary."

NOTE 2.—It is prescribed in Article 21 of the Regulations, that "in narrow channels every Steamship shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such Ship."

NOTE 3.—For Steamship's optional signals, see Article 19 of the Regulations.

Rules concerning the Lights or Signals to be carried, and concerning the Steps for avoiding Collision to be taken, by Vessels navigating the River Mersey.*

1. Every vessel exceeding ten tons measurement, including river craft, while navigating, or anchored, or moored in any part of the River Mersey, shall, from and after the 1st day of February, 1881, observe and obey the new "Regulations for preventing Collisions at Sea," as set out in the First Schedule annexed to an Order in Council made in pursuance of the Merchant Shipping Act Amendment Act, 1862, and dated the 14th day of August, 1879, and as varied and amended by an Order in Council made as aforesaid, and dated the 24th day of March, 1880, with the exceptions and additions mentioned in the following rules.

2. Canal flats and all other vessels without masts, whilst being towed, shall carry the lights prescribed for sailing vessels by Article 6 of the said "Regulations for preventing Collisions at Sea."

3. In addition to the lights for a steam vessel towing another vessel, prescribed by Article 4 of the said Regulations, such steam vessel shall carry a bright White Light showing astern as a guiding light to the vessel or vessels being towed.

4. Instead of the light prescribed by Article 8 of the said Regulations, every vessel when at anchor in the River Mersey shall carry two White Lights in globular lanterns of not less than eight inches in diameter, and so constructed as to show a clear, uniform, and unbroken light visible all round the horizon for at least one mile, one of which lights shall be placed at a height not exceeding twenty feet above the hull on the forestay, or otherwise near the bow where it may best be seen, and the other at the main or mizen peak, or on the boom topping lift, or other position near the stern, at double the height of the bow light before mentioned.

* Dock Office, Liverpool, January, 1881.

5. Instead of the light prescribed by Article 11 of the said Regulations, a bright White Light similar to the lights mentioned in Rule 4 shall be shown continuously from the stern rail of every vessel, while under way and in motion, in all weathers, between sunset and sunrise.

6. A vessel anchored to mark the position of a wreck or other obstruction, shall carry, in all weathers, from sunset to sunrise, two bright White Lights, similar to those mentioned in Rule 4, which lights shall be placed horizontally on a cross yard on the foremast, at a height not exceeding twenty feet above the hull and twenty feet apart. And the said vessel shall carry, in all weathers, between sunrise and sunset, two black balls placed as hereinbefore ordered with regard to the lights aforementioned.

Thames Rule for regulating the Traffic above the Nore.

"If a sailing vessel and a steam vessel are proceeding in such a direction as to involve risk of collision, the steam vessel shall keep out of the way of the sailing vessel: provided, however, that if, owing to causes beyond the control of those navigating the steam vessel, it is unsafe or impracticable for the steam vessel to keep out of the way of the sailing vessel, the steam vessel shall signify the same to the sailing vessel by four or more blasts of the steam whistle of about two seconds duration in rapid succession: and the sailing vessel shall then keep out of the way of the steam vessel."

United States.

Extracts from the Rules and Regulations for Inland Waters.

Rule 1. When steamers are approaching each other, the signal for passing shall be one sound of the steam whistle to keep to the right, and two sounds of the steam whistle to keep to the left.

These signals are to be made first by the ascending steamer. If the dangers of navigation, darkness of the night, narrowness of the channel, or any other cause, render it necessary for the descending boat to take the other side, she can do so by making the necessary signals, and the ascending steamer must govern herself accordingly. These signals are to be observed by all steamers, either day or night.

Rule 2. Should steamers be likely to pass near each other, and these signals should not be made and answered by the time such boats shall have arrived at the distance of eight hundred yards from each other, the engines of both boats shall be stopped: or should the signal be given and not properly understood, from any cause whatever, both boats shall be backed until their headway shall be fully checked, and the engines shall not be again started ahead until the proper signals are made, answered, and understood.

Rule 3. When two boats are about to enter a narrow channel at the same time, the ascending boat shall be stopped below such channel until the descending boat shall have passed through it; but should two boats unavoidably meet in such a channel, then it shall be the duty of the pilot of the ascending boat to make the proper signals, and when answered by the descending boat, to lie as close as possible to the side of the channel the exchange of signals may have determined, as allowed by Rule 1, and either stop the engines or move them so as only to give the boat steerage way, and the pilot of the descending boat shall cause his boat to be worked slowly until he has passed the ascending boat.

Rule 4. When a steamer is ascending and running close on a bar or shore, the pilot shall in no case attempt to cross the river when a descending boat shall be so near that it would be possible for a collision to ensue therefrom.

Rule 8. When steamers are running in the same direction, and the pilot of the boat astern shall desire to pass on either side of the boat ahead, he shall give the signal as in Rule 1, and the pilot of the boat ahead shall answer by the same signal, and allow the other to pass on the side selected, and shall in no case attempt to cross her bow or crowd upon her course.

Rule 10. Doubts or fears of misunderstanding signals may be expressed by several short sounds of the whistle in quick succession.

Steering Rules in French Merchant Service.

The Board of Trade have drawn attention to a Decree issued by the President of the French Republic, assimilating the rules for the Steering of Merchant Vessels to those observed on board French Ships of War.

In accordance with this Decree the orders to "Starboard" or "Port," as well as the signs and signals used to confirm or repeat such orders, will indicate not that the *helm is to be put over* to "Starboard" or "Port," but that the *ship's head may go to* "Starboard" or "Port."

This change in the French regulations should be borne in mind, with a view to avoid collisions, on occasions when French pilots are employed on board British Ships.

Official Notice—Merchant Shipping Act, 1873.

Collisions.

The Board of Trade give notice, that on and after the 1st of November, 1873, the following Sections (16 and 17) of the Merchant Shipping Act, 1873, come into operation.

16. "In every case of collision between two vessels, it shall be the duty of the Master or person in charge of each vessel, if and so far as he can do without danger to his own vessel, crew, and passengers (if any), to stay by the other vessel until he has ascertained that she has no need of further assistance, and to render to the other vessel, her Master, crew, and passengers (if any), such assistance as may be practicable and as may be necessary in order to save them from any danger caused by the collision; and also to give to the Master or person in charge of the other vessel the name of his own vessel, and of her port of registry, and of the port or place to which she belongs, and also the names of the ports and places from which, and to which she is bound.

"If he fails so to do, and no reasonable cause for such failure is shown, the collision shall, in the absence of proof to the contrary, be deemed to have been caused by his wrongful act, neglect, or default.

"Every Master or person in charge of a British vessel who fails without reasonable cause to render such assistance, or give such information as aforesaid, shall be deemed guilty of a misdemeanour; and if he is a certificated officer, an inquiry into his conduct may be held, and his certificate may be cancelled or suspended.

17. "If in any case of collision it is proved to the Court before which the case is tried that any of the regulations for preventing collisions contained in or made under the Merchant Shipping Acts, 1854 to 1873, have been infringed, the ship by which such regulation has been infringed shall be deemed to be in fault; unless it is shown to the satisfaction of the Court that the circumstances of the case made departure from the regulations necessary."

THOMAS GRAY, one of the Assistant Secretaries.

Marine Department, Board of Trade, September, 1873.

SECTION IV.

PILOTING—COMMON AND PROPER—WIND—WEATHER—BAROMETER — THERMOMETER — CURRENTS — ICE — GREAT CIRCLE SAILING—PASSAGE TABLES.

PILOTING—COMMON AND PROPER.

IT is here thought necessary to call special attention to that most important duty in a sailor's profession, viz. the Piloting of the vessels committed to his charge.

The art of Piloting was divided by the old navigators into two parts: Common and Proper.

Common Piloting is that knowledge which teaches how to coast along shore, or to sail or steam within sight of land.

Proper Piloting is that knowledge which teaches how to sail or steam across the ocean out of sight of land, and to navigate by celestial instead of by terrestrial bodies.

To insure success in Common Piloting, a thorough knowledge is required of the coast and waters on which the ship may be sailing; but as it frequently happens, in the absence of a local pilot, that the sailor has to depend upon himself, the methods and instruments by means of which such knowledge can be acquired should be made the serious study of the navigator. Fortunately, such methods and instruments are easy of access, and it only remains for the sailor by constant practice to acquire facility in understanding the former and handling the latter, remembering that the constant exercise of such duties in the opportunities afforded by fair weather, will enable him to conduct his vessel with greater safety in foul weather.

Mariner's Compass.—Attention is first called to the Mariner's Compass, which instrument in these days of iron ship-building should be well understood, its peculiar deviation carefully ascertained, and the changes in that deviation constantly watched.*

* The best Standard Compass is that invented by Sir William Thomson. Its mechanical construction is as near perfection as may be; and, looking at it either theoretically or practically, it has advantages which no other known mariner's compass possesses.

The Anchor and Cable, also important implements in Common Piloting, should be always ready for use, and not be lost sight of as valuable auxiliaries until the vessel has fairly left the land.

The Chart should not only be always at hand, but also be thoroughly understood; and as considerable information is to be obtained from every mark delineated thereon, the necessary abbreviations (*see* Section V.) should be so well comprehended, that they may be read at sight.

In fair weather the coast in sight should be watched with the chart, so that the sailor may become accustomed to recognize the land as drawn upon the chart, the various points being observed as the vessel moves along, and the changes in their appearance as seen from different aspects carefully noted. Every light and buoy should be observed as to its position, character, and colour, so that they may be known again when encountered under less favourable circumstances, or reported upon if found out of position.

It must also be remembered that through the changes that are constantly occurring in the charts, through the erection of new lighthouses, improvements and alterations in the character of the old lighthouses, the changes that necessarily happen in the buoyage of channels, the discovery of new dangers, and the variations that in course of time naturally take place in the mouths of rivers, a ship's charts perpetually require correction. The Admiralty and Trinity House issue from time to time *Notices to Mariners*, giving full information upon these alterations, which it is the duty of the sailor to see made upon his charts. In 1881 fifty-eight new editions of charts were issued by the Admiralty, while no less than 2500 charts received correction for alterations that had taken place. The date of every correction made to an Admiralty chart is noted on the foot of the chart; either in full against the imprint, or in Roman numerals in the left-hand corner.*

* The Board of Trade has issued the following Official Notice upon this important subject:—

Incorrect Charts.—Notice to Shipowners and Agents.

The attention of the Board of Trade has frequently been called to cases in which British Vessels have been endangered or wrecked through Masters attempting to navigate them by means of antiquated or otherwise defective Charts.

The Board of Trade desire, therefore, to direct the especial attention of Shipowners, and their Servants and Agents, to the necessity of seeing that the Charts taken or sent on board their ships *are corrected down to the time of sailing*. Neglect to supply a ship with proper Charts will in future be brought prominently before the Court of Inquiry in the event of a wreck occurring from that cause.

THOMAS GRAY,
Assistant Secretary Marine Department.

By Order of the Board of Trade,
March, 1882.

The Sextant should be always at hand, as a means to obtain the ship's position by horizontal angles. The sextant, from its delightful portability, can frequently be used when masts, sails, funnels, heel of ship, or important passengers, obstruct the view from the compass. The angular distance between objects on shore are more readily and accurately measured by the sextant, than by bearings of those objects taken by the compass. When possible, however, a compass bearing of one of the objects used to fix the position of the ship, should be observed at the same time as the angles are taken. (See "Determining Positions," Section V.)

The sextant should also be used to measure the vertical angles of peaks, headlands, or lighthouses whose heights are known, by which means (assisted by Captain Lecky's "Danger Angle and Off-shore Distance Tables" *) a ship may round a headland in safety when no other mode of determining her distance from it might be available.

The protractor, dividers, and parallel rulers and pencil should be found in brackets or racks screwed to the bulkhead in the neighbourhood of the chart.

The Tides and Currents will require serious attention, and as they are always considerably affected by the prevailing weather, constant watchfulness is required to enable the sailor to handle these useful forces. The log should be regularly hove, or if the patent log is used, it should be frequently observed; attention to the log, combined with good steerage, and obtaining the vessel's position by means of bearings, etc., being the methods by which the movements of the water can be understood. A few simple methods by which a ship's position can be readily obtained when in sight of the land will be found fully explained in Section V.

The Barometer and Thermometer observed conjointly, will also enable the intelligent seaman to acquire a knowledge of wind and weather.

The Rule of the Road should be so thoroughly mastered, that there would be no hesitation in the action to be taken in meeting or passing vessels, by night or day, whether under steam or sail. The sailor should be as familiar with these laws as he is with the points of his compass, so as to enable him to move his ship as instinctively as he moves his own body. Helmsmen should be often tried to ascertain that they were able to carry out correctly and quickly the important orders of "Port" and "Starboard." The state of the bow lights as well as that of the masthead lights should be the constant care, not only of the officer of the deck, but also of the look-out man. The steam

* Published by George Philip and Son, London and Liverpool.

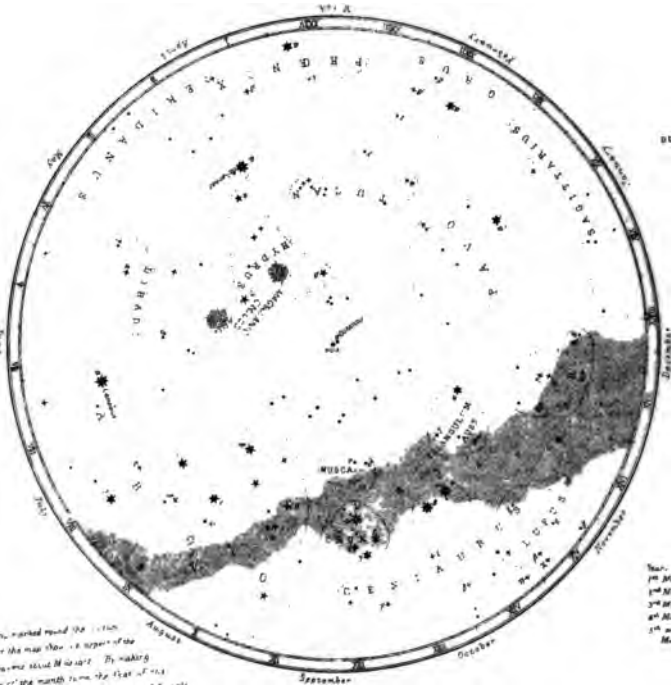
whistle, or fog-horn of a sailing vessel, should always be known to be in a state of efficiency in case of the vessel encountering the sailor's worst enemy, a fog, during which time his vigilance should be increased, and arrangements made for rapid and instant action on meeting or passing another vessel. Speed must be considerably reduced during a fog, boats must be ready for lowering, and every preparation made to prevent loss of life in one of the most serious difficulties that has to be overcome at sea.

The Lead.—Above all, the sailor's attention is most earnestly called to that simple but important instrument, to that best of all inventions, for saving life at sea, viz. *the Lead;* the neglect of which may be said to have been the great cause of modern disasters to shipping. The Lead, deep sea as well as hand, should never be lost sight of, and the crew (and even passengers) made familiar with the method of "passing the line along," so as to obtain a deep sea cast with as little delay as possible. The lead should always be armed, and the soundings and nature of the bottom obtained by each cast of the lead should be compared with that shown in the supposed position of the vessel on the chart. "It should be borne in mind when approaching the land, that even under the most favourable circumstances the use of the lead is desirable; but, when from the state of the weather and consequent absence of celestial observations, a ship's position is dependent on dead reckoning, *the lead becomes of primary importance, and its constant use indispensable to safe navigation.*" * In obtaining a deep sea sounding a little delay may be incurred in "passing the line along," but the length of the modern steam vessels gives great facility to the performance of this simple act of seamanship; the engines might be eased and bottom obtained; thus securing, at a very small expenditure of time, the safety of life and property. The use of Sir William Thomson's Sounding Machine, a simple but invaluable instrument described in Section V., will much facilitate the operation of deep sea sounding.

Coral Reefs.—The secret of successful navigation among coral reefs where the lead is of little use, is to sail or steam with the sun astern of the vessel, conning her from the masthead. The vicinity of coral reefs is often indicated by what is known as "white water," but generally the reefs show as dark green patches.

* Admiralty Channel Pilot.

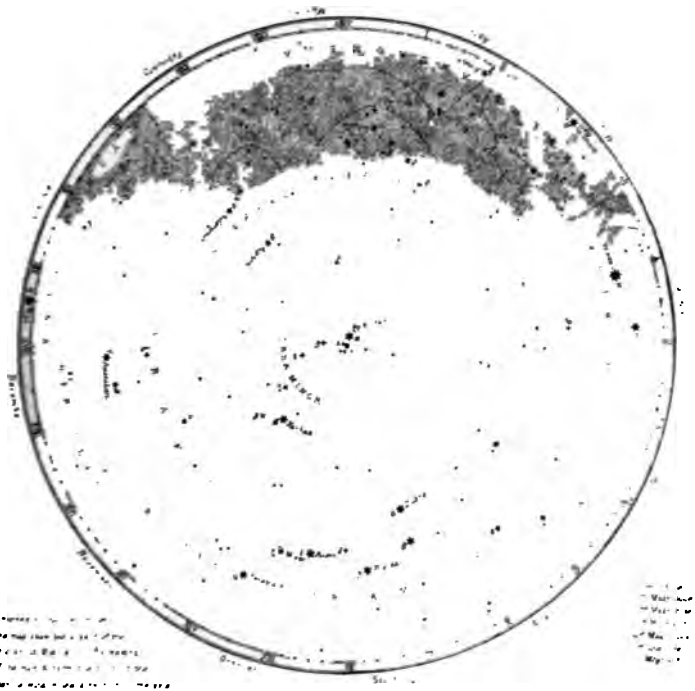
SOUTHERN CIRCUMPOLAR CONSTELLATIONS
TO DECLINATION 40° S.



The centre marked round the circumference of the map shows the aspect of the heavens at about 10 o'clock. By making the name of the month to the first of the map and, on looking in the direction of the pole, the different constellations will readily be recognised

GRIFFIN & Co., PORTSMOUTH.

NORTHERN CIRCUMPOLAR CONSTELLATIONS
TO DECLINATION 40° N.



PROPER PILOTING.

GH this branch of the art appears to open a wider field of know-
'et, as in Common Piloting, the sailor still finds himself dependent
few well-known works and instruments; he now uses celestial instead
strial bodies as his guides. Constant observations of sun, moon, and
: therefore required.

Chronometer, an instrument fully described in Section V., plays
rtant part in Proper Piloting. At the same time lunars should not be
d; in case of disaster to the chronometer, or circumstances occurring,
an officer having to navigate a prize without a chronometer, this old
of obtaining longitude would be found extremely useful. In taking
stars lying at about equal distances east and west of the moon should
en for observation, in order to counteract the instrumental error of the

Sextant should be always at hand; obtaining sights in cloudy
r in mid ocean is good practice for doing the same thing when nearing
l, and observations are more valuable; for the same reason the ship's
should frequently be determined by means of stars observed north
ith of the zenith. A good longitude can also often be obtained by
ken just before sunrise or just after sunset. Sumner's method (see
V.) for fixing the ship's position should be thoroughly understood, and
practised. Amplitudes and Azimuths should be constantly taken to
: total error of the Standard Compass.

rs.—Attention is earnestly called to these great aids to Navigation.
sailor should learn

> "To know night's goodly company of stars,
> And those bright lords that deck the firmament."

is no difficulty in taking stellar observations at sea; the operation re-
only that capacity for taking trouble which is natural to the true
while the calculations are short, simple, and merely require practice.
tar maps, two polar, and two equatorial, have therefore been inserted,
ch means a fair representation of the heavens is given for any season
year, or for any part of the world.

e **Dead Reckoning** should be carefully kept, and constant com-

parison made between the currents actually experienced and those noted upon the charts. Constant attention being paid to the Standard Compass, the log, and the steerage, engenders confidence in the dead reckoning that may be useful in making the land in cloudy weather. As a careful departure should be taken on leaving the land, so the ship's position should be fixed by the land as soon as possible after it is made, making a good landfall being a point of honour with the proper pilot. In both leaving and making the land, its height, and therefrom the distance it can be seen from sea, should be taken into consideration. In observing the altitude of peaks, etc., to determine their distance from the ship, care should be taken to obtain the altitude both "on" and "off" the arc of the sextant.

The Wind and Current Charts now published by the Hydrographic Office of the Admiralty should be obtained and studied; as from a thorough knowledge of the Winds and Currents the best methods of making passages across the ocean can alone be found out. The Sailing Directions treating upon passages, and those also that describe the coasts to which the vessel is bound, should be studied during the voyage, to insure some acquaintance with the land about to be made, and knowledge of the winds, currents, and tides in its vicinity. The regions wherein ice may be fallen in with, and seasons at which this danger is liable to be encountered, should be known. The Law of storms should be well understood; with the locality, and seasons in which Hurricanes prevail; as also the best means of avoiding the vortex, if one of these phenomena should be fallen in with.

In Conclusion, the sailor's attention is earnestly called to the foregoing brief notes upon Piloting—Common and Proper. Theoretically, the subjects treated upon may appear so simple as to be adapted to the meanest capacity, and a perusal of these notes possibly may raise a smile upon the face of the apparently learned. But however easy navigation may appear to the student when carried on free of anxiety or danger in a comfortable college *on shore*, Pilotage—Common and Proper—will be found to be a very different business when pursued in a gale of wind at night, or in hazy weather, on board a ship *at sea*. Proficiency in the science and handicraft of piloting can only be attained by incessant practice at sea, and requires a capacity for taking trouble and unremitting attention. The true secrets of the sea cannot be learned upon the shore;* and the poet has truly sung with regard to the sea that

> "Only those who brave its dangers,
> Comprehend its mystery."

* Some of these "secrets" are well told to sailors by S. T. S. Lecky, R.N.R., in his *Wrinkles in Practical Navigation*, published by George Philip and Son, London and Liverpool.

The Beaufort Notation, to Indicate the Force of the Wind.

0—Denotes calm.		
1—Light air: just sufficient to give steerage way.		
2—Light breeze	With which a well-conditioned Man-of-war under all sail and clear full, would go in smooth water.	1 to 2 knots.
3—Gentle breeze		3 to 4 knots.
4—Moderate breeze		4 to 5 knots.
5—Fresh breeze	In which the same ship could just carry close-hauled	Royals, etc.
6—Strong breeze		Single reefs and top-gallant sails.
7—Moderate gale		Double reefs, jib, etc.
8—Fresh gale		Triple reefs, courses, etc.
9—Strong gale		Close reefs and courses.
10—Whole gale	With which she could only bear	Close-reefed main top-sail, and reefed fore-sail.
11—Storm	With which she would be reduced to	Storm staysails.
12—Hurricane	To which she could show	No canvas.

Rate		Pressure	Description of Wind.
Miles per hour	Feet per minute	Force in lbs. per square foot	
1	88	·005	Hardly perceptible
2	176	·020	Light air
3	264	·044	
4	352	·079	Gentle breeze
5	440	·123	
10	880	·492	Fresh breeze to strong breeze
15	1320	1·107	
20	1760	1·970	Moderate gale
25	2200	3·067	
30	2640	4·429	Strong gale
35	3080	6·027	
40	3520	7·870	Whole gale
45	3960	9·900	
50	4400	12·304	Storm
60	5280	17·733	Great storm
70	6160	24·153	
80	7040	31·490	Hurricane
100	8800	49·200	

INFORMATION ON THE AVERAGE LIMITS OF THE REGIONS OF TRADE WINDS AND MONSOONS; WITH THE LOCALITIES OF CYCLONIC STORMS AND RAINY SEASONS IN THE ATLANTIC, PACIFIC, AND INDIAN OCEANS, THROUGHOUT THE YEAR.

ATLANTIC OCEAN.

AVERAGE LIMITS OF THE TRADE WINDS.

Months.	Jan., Feb., March.	April, May, June.	July, Aug., Sept.	Oct., Nov., Dec.
N.E. Trade — Northern Boundary	October to April—A line drawn from the Canaries to Havana.			
N.E. Trade — Southern Boundary *	April to October—A line drawn from Madeira to Havana.			
N.E. Trade — Southern Boundary *	2° N.	4° N.	11° N.	6° N.
Breadth of Variable Belt	120 Miles	180 Miles	500 Miles	200 Miles
S.E. Trade — Northern Boundary †	The Equator	1° N.	3° N.	3° N.
S.E. Trade — Southern Boundary ‡	A line drawn from the Cape of Good Hope to the Isles of Trinidad and Martin Vaz.			
RAINY SEASONS.	Guayana and North Brazil. — Africa south of the Equator.	Guayana, Brazil, and Africa (north of the Equator) in May and June; Carribean sea in June.	West Indies and Africa (north of the Equator). — Brazil in July and August.	Guayana in Dec., Africa (south of the Equator) in Nov. and Dec.
CYCLONES.			West Indies.	West Indies in Oct., and occasionally in Nov.

* Between Cape Verde and Sierra Leone, extending fifty to seventy leagues from the shore, winds and currents change with seasons. From June to September squally S.W. winds, and a N.E. or northerly current. From October to May, when N.E. and northerly winds prevail, a south-easterly current is experienced.

† On the Brazilian coast, southward of Bahia, the winds blow from N.N.E. to E., between October and March; and between April and September from S.W. and S.E.

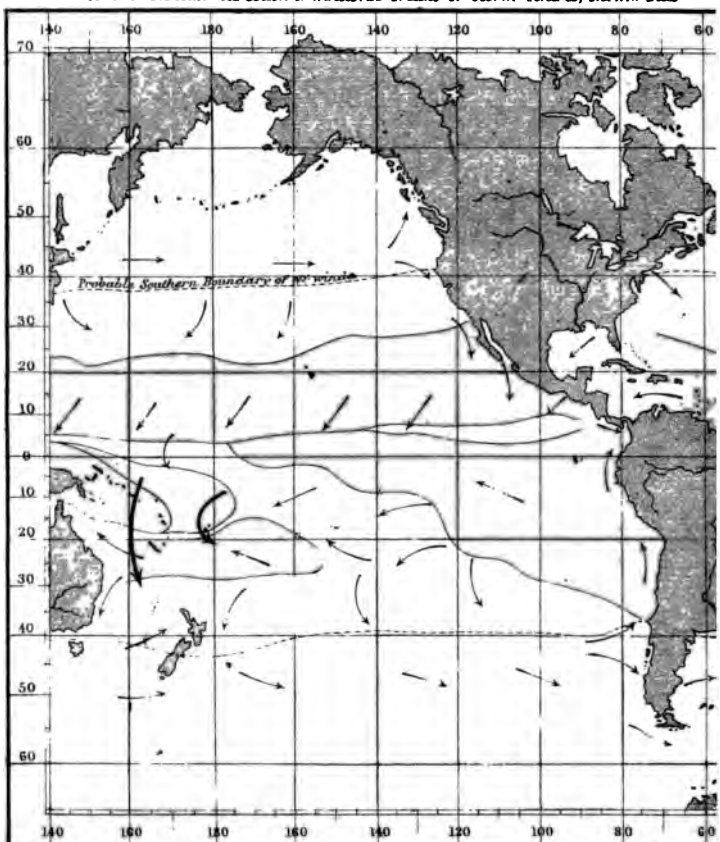
‡ South and S.W. winds prevail on the West Coast of Africa, south of Sierra Leone, all the year round. A line drawn from Walfisch Bay, in about 23° S., to Cape Palmas will form the general boundary between these winds and the S.E. Trade. December to February is the Harmattan season on African coast, northward of the Equator.

See Page 96 to 99.

WIND CHART FOR J

Compiled by Commander Thomas F

Arrows indicate direction of winds. — Tracks of storm centres, shewn thus ——



Drawn for the "Sailor's Pocket Book".

* *Although compiled especially representation of the winds*

FEBRUARY & MARCH.*

perintendent of Admiralty Charts.

onsoon, coloured Blue. — S.E. Trade, coloured Red. — N.W. Monsoon, coloured Brown.

this, this Chart also gives a fair
ression between November and April.

PACIFIC OCEAN.

Average Limits of the Trade Winds Eastward of the Meridian of 160° W.

Months.		Jan., Feb., March.	April, May, June.	July, Aug., Sept.	Oct., Nov., Dec.
N.E. Trade	Northern Boundary	28° N.	29° N.	31° N.	28° N.
	Southern Boundary	8° N.	10° N.	12° N.	11° N.
Breadth of Variable Belt		*300 Miles.	450 Miles.	†180 Miles.	300 Miles.
S.E. Trade	Northern Boundary	4° N.	4° N.	9° N.	6° N.
	Southern Boundary	A line drawn from Juan Fernandez through Easter Island and the Marquesas.	A line drawn from St. Felix Island towards Tahiti, as far as the Mer. of 135° W.‡	A line drawn from St. Felix Island to Tahiti.	A line drawn from Valparaiso towards Tahiti, as far as the Mer. of 135° W.‡
RAINY SEASONS.		Sandwich Islands and Coast of Ecuador. — South Pacific Islands.	Mexico and Central America in June.	Mexico and Central America.	Sandwich Islands and Coast of Ecuador in December. — South Pacific Islands in Nov. and Dec.
CYCLONES.				Mexico in Aug. & Sept.	Mexico in October.

* This is near the American coast. In long. 160° W., but little Variables will be experienced.

† Eastward of the meridian of 123° W., the region of the Variables, with S.W. and southerly winds, falls within a triangle formed by the American coast between the Northern Tropic and the Equator, and lines drawn from these points to lat. 10° N., and long. 130° W.

‡ In the neighbourhood of Tahiti, and the Low Archipelago, the trade winds frequently veer to the N.E. at these seasons.—*See* p. 98.

PACIFIC OCEAN.

Winds Westward of the Meridian of 160° W.

THE N.E. Trade in this part of the Pacific is much affected by the extensive Archipelagos of the Marshall, Caroline, and Gilbert Islands; while to the westward of the Mariana Islands, the S.W. Monsoon of the China Sea extends in April, May, and June to the Meridian of 136° E., and in July, August, and September to the Meridian of 146° E. The region of the N.E. Trade may be said to lie between the parallels of 22° N. and 4° N.; and of 28° N. and 10° N., according to the season of the year. Southward of the N.E. Trade, from October to April, the winds blow fresh from the northward and westward, with violent gales from the S.W., and heavy rain.

In a similar manner the S.E. Trade of this part of the Pacific is affected by the numerous islands lying between the Marquesas and the Australian coast. The S.E. Trade can be said to blow fairly across the South Pacific only in July, August, and September; and is then found between the parallels of 8° N. and 22° S. During the remaining nine months of the year, the direction of the Trade in the neighbourhood of the islands becomes more N.E. than S.E.

To the southward of the Islands and towards the Australian coast, the S.E. Trade will again be found extending between December and March, as far south as the parallel of 28°.

Between the months of November and March, this part of the Pacific may be said to be invaded by the N.W. or Middle Monsoon of the Indian Ocean, blowing with less certainty than in that ocean, but constantly experienced as far east as the Marquesas and as far south as the 20° parallel; this wind blows with diminished force, and less prevalence as it approaches those islands. This is the bad and wet season of Polynesia; and even where the S.E. Trades prevail, they are often found to be light and uncertain. Hurricanes have been experienced in January, February, and March.*

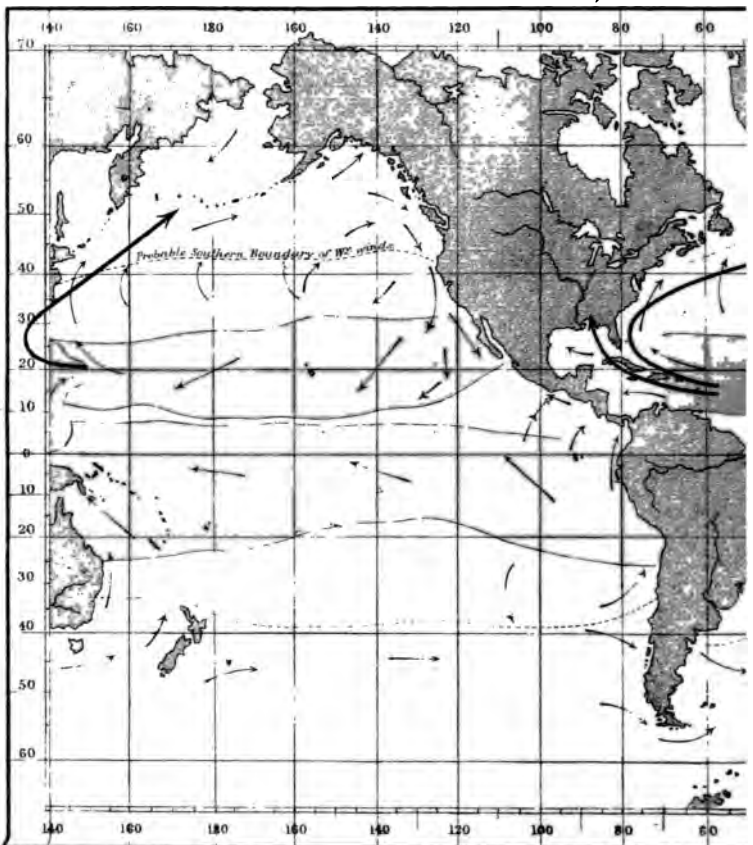
* For more detailed information on the winds, weather, and currents between the Australian coasts and Low Archipelago, reference must be made to the wind and current charts for the Pacific, Atlantic, and Indian Oceans, by Captains Evans and Hull, R.N., and published by the Hydrographic Office of the Admiralty.

See Page 96 to 99.

WIND CHART FOR JUI

Compiled by Co[illegible] Thomas A. Hu

Arrows indicate direction of winds. Tracks of storm centres, shewn thus ⟶.



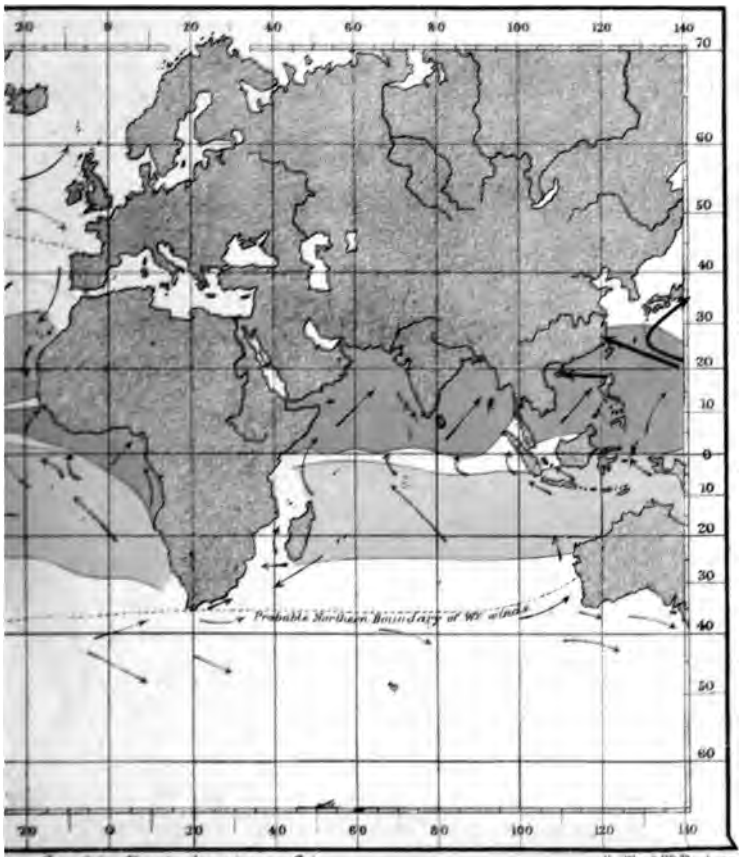
Drawn for the "Sailor's Pocket Book".

* *Although compiled especially for representation of the winds th*

GUST & SEPTEMBER.*

Superintendent of Admiralty Charts.

te, coloured Blue S.E. Trade, coloured Red S.W Monsoon coloured Purple



months, this Chart also gives a fair
experienced between May and October.

Griffin & Co. Portsea

Winds in the Indian Ocean.

ARABIAN SEA.	BAY OF BENGAL.	CHINA SEA.
November to March. N.E. MONSOON. *Moderate and Fine.*	November to March. N.E. MONSOON. *Moderate and Fine.*	October to April. N.E. MONSOON. *Blows fresh in Nov., Dec., and Jan.*
May to September. S.W. MONSOON. Blowing fiercely, with bad weather in June and July; moderating in August.	May to September. S.W. MONSOON. Blowing fresh, with bad weather in June and July; moderating in August.	May to September. S.W. MONSOON. Moderate, with rain, strongest in June, July, and August.
Cyclones in April and May; and from Oct. to Dec.		Typhoons from July to Nov.

East Coast of Africa and the Mozambique Channel.

December to March—
Northerly winds.

May to November—
Southerly winds.

Between the Equator and the Parallel of 10° S.

November to March.

N.W., OR MIDDLE, MONSOON.

Light, with squalls, rains and frequent calms. From the Seychelles to the African coast the N.E. Monsoon prevails.

May to September.

S.E. TRADE.

Light with frequent calms northward of the parallel of 4° S., and veering to the S.W. between the meridian of 80° E., and coast of Sumatra.

Between the Parallels of 10° and 27° S.

CONSTANT S.E. TRADE.—Cyclones from December to April.

General Remarks on the Winds and Weather of the Malay Archipelago.

North of the Equator.—North-easterly winds, varying at times to N.W., prevail from December to March inclusive. This is the fine season, the winds blowing strong and steadily, except in the Sulu Sea, where variables prevail.

Southerly and south-westerly winds prevail from May to September inclusive. This is the wet season, and the winds are variable in force and direction with bad weather. Sudden and violent squalls from the north-west occur in the Celebes and Sulu seas.

October and November are unsettled months; the N.E. Monsoon not being fairly established before the middle of December.

Malacca Strait.—On account of the high land on either side of this strait, the monsoons are irregular and the winds variable; but land and sea breezes prevail on both coasts. The S.W. Monsoon begins off Acheen Head in May, and ceases in October; it seldom blows far into the strait. During this season the weather is generally cloudy and stormy with rain, especially in July and August.

The N.E. Monsoon prevails off the northern entrance to the strait from November to April, but within the strait N.W. and W. winds, lasting for one or two days, have been experienced in every month. This is the fair season, and there is less thunder, lightning, rain, and squalls than between May and October.

Molucca Passage.—From a register, kept by the surgeon of the Dutch settlement at Ternate, in lat. 0° 48′ N., extending over a period of eight years, from 1860 to 1867 inclusive, it was deduced that the N.E. Monsoon blows through January, February, and March, the wind varying from N.E. to N.W. After a month of variable winds, the S.W. Monsoon commences in May and ends in October, its direction being from S.E. to S.W. During November and December the winds are again variable.

Rain fell on 216 days of each year, or 18 days per month; the average fall during the N.E. Monsoon being rather less than during the S.W. Monsoon. The mean temperature for each of the above eight years was 80·7° Fahr.

On the eastern or Pacific coasts of the Philippine Islands, however, the northerly winds bring bad weather, and southerly winds comparatively fine

weather. The monsoons are less regular on the Pacific coasts of these islands than in the China Sea; the southerly monsoon off Luzon beginning in June.

Typhoons may be experienced off the north end of Luzon in September and October.

South of the Equator.—West and N.W. winds veering to N.E. prevail from November to March. On coasts having a northern aspect, land and sea breezes, with unsettled weather and rain, will be found.

South-east and E. winds prevail from May to September; generally fresh and steady, with fine weather, on coasts with a northern aspect, but bringing rain and bad weather to coasts open to the southward.

Banda Sea.—From a meteorological register kept at Amboina, in lat. 3° 41′ S., extending over a period of four years ending 1874, it would appear that the N.W. Monsoon commences about November and lasts till April; but only during January, February, and part of March do the winds blow steadily, and then between N. and N.W. The S.E. Monsoon blows from May to the beginning of September, after which it becomes variable to the end of November. In December the wind is variable from N. through W. to S., and in March and April from N.W. to S.W.

Rain falls in every month of the year, the driest season being from October to April inclusive, with an average of thirteen days' rain and eight inches' fall for each of these months. The other months average twenty-one days' rain, with a fall of twenty-seven inches. The mean temperature for the whole year ranges from 74° to 86° Fahr.

On comparing the records of the weather at Ternate with those at Amboina and stations eastward, it would appear that, during the periods of its greatest strength, the N.E. Monsoon, passing through the Molucca passage, turns eastward and becomes the N.W. Monsoon in the Banda and Arafura seas; and that the S.E. Monsoon, blowing through the Arafura and Banda seas, bends into the Molucca passage, and joins the S.W. Monsoon in the Pacific.

The changes in the direction of the winds in this locality will be seen to be a corroboration of those shown on the Admiralty Wind Charts.

New Guinea.—On the west coast of New Guinea are also two monsoons, the S.E. lasting from April to October, and the N.W. beginning at the end of October, and terminating in April.

In January the wind sometimes varies from N.N.W. to N.E. In March, April, and May the weather is changeable and squally. From June to September a great deal of rain falls; October to May may be considered as the fine season.

Arafura Sea.—In the Arafura and Timor seas the Easterly Monsoon blows with its greatest regularity; between May and August it is fresh from E.S.E. to S.E.; earlier and later in the season it hangs more to the E., and often veers to E.N.E.

Torres Straits.—The Westerly Monsoon begins in December and lasts until April; this monsoon is frequently interrupted by easterly winds, and the weather is rainy, bad, and uncertain. In April the Easterly Monsoon commences with squalls and rain, but soon becomes settled, with comparatively fine weather. In April and November, when the monsoons change, long calms are often experienced. November is most liable to calms. At the approach of the N.W. Monsoon westerly winds often blow for a week, and are then succeeded by some ten days of light variable airs; the true monsoon then sets in with rain and squalls, clearing with finer weather as the season advances. The general direction of the wind is W.N.W. to W.S.W., veering at times to N.W. and S.W.

South of Java and Timor the Western Monsoon prevails from December to February inclusive, as far south as a line drawn from Christmas Island to lat. 15° S. on the Australian coast. The winds vary from S.W. to W., and sometimes N.W., blowing fresh with squalls and rain, but interrupted by frequent calms. Hurricanes also occur during this season of the year.

From April to November inclusive, the S.E. Trade is established, blowing steadily with fine weather.

Calms are frequent at all seasons of the year between the Malay Archipelago and the northern coasts of Australia.

Rainy Seasons.—In the Malay Archipelago, situated as it is in the vicinity of the Equator, and within the regions of calms and doldrums caused by the meeting of the northern and southern wind systems, the wet and dry seasons are not strongly contrasted, as a great amount of rain falls more or less all the year round. The same monsoon is often stormy at sea, but fine near the land; as a rule, bad weather with rain is felt on coasts and islands *towards* which the wind blows: whilst coasts *from* which the wind blows enjoy finer weather.

Dampier's remarks upon the Pacific coasts of Central America will also apply to these regions. He says, "It is a very wet coast and it rains abundantly here all the year long. There are but few fair days; for there is little difference in the seasons of the year between the wet and the dry; only in that season which should be the dry time, the rains are less frequent and more moderate than in the wet season, for then it pours as out of a sieve."

HURRICANES, CYCLONES, TYPHOONS.

These storms are progressive revolving gales of unusual violence, and may be generally described as great whirlwinds turning round and rolling forward at the same time. The average rate of the progressive movement of the centre or focus of the West Indian hurricanes is about 300 miles a day; of those on the Malabar coast, Bay of Bengal, and China Sea, 200 miles a day, and often less; whilst the Cyclones of the South Indian Ocean vary in their rate of progress from 200 to 50 miles in the twenty-four hours.

Within the tropics the effects of these storms are often felt 100 miles on either side of the central track, this limit expanding in the extra-tropical regions.

The Regions where, and the Seasons in which these Storms prevail are as follows:—

Hurricanes.—In the West Indies and on the east coast of North America: and on the coasts of Mexico and Lower California in North Pacific Ocean—July to October, and occasionally November.

In South Pacific Ocean, between Australian coast and Low Archipelago—December to March.

Cyclones.—Malabar Coast and Bay of Bengal—April and May; and October to December. South-Indian Ocean—December to April.

Typhoons.—China Sea—July to November. Coasts of Japan—August, September, October.

The peculiar characteristic of the revolving action of these storms is, that in each hemisphere of the world the gyration invariably takes place in one direction, and that direction contrary to the apparent course of the sun; so that in north latitudes these storms revolve from right to left, and in south latitudes from left to right. The knowledge of this law is the more especially important, as it not only supplies the seaman with direct means of distinguishing them from common gales, but it reveals to him the probable position of the centre or vortex with respect to the place of his vessel, and therefore points out the way of escape from them.

In all cases within the tropics, they commence to the eastward. For some days they travel along a path not exactly west, but inclining a point or two

towards the pole of the hemisphere which they are crossing: and, as they advance, they seem to be more inclined to curve away from the Equator. When they reach the 25th degree of latitude, they generally curve still more until they move to the N.E. in the northern hemisphere, and to the S.E. in the southern hemisphere. Occasionally they are found to cross the line of the shore, and to sweep over the land that opposes their progress, as appears to be generally the case in the East Indies and China Sea; but by far the greater number seem to be repelled by the land, so as to be deflected back to the N.E. in the northern hemisphere and to the S.E. on the other side of the Equator. The Atlantic and Japan storms, for instance, almost always wheel round to the northward, and follow the sea-board of North America or Japan.

Another remarkable feature of these storms, is their increasing violence in the neighbourhood of their centre or vortex; and as this is approached (unless on the direct line of its own progressive motion), the more rapid become the changes of the wind, which at length, instead of veering point by point, as on entering the storm-field, now flies round at once to the opposite point.

With that threatening aspect of the sky which generally foretells bad weather, every seaman is acquainted; in addition to this a confused and troubled agitation of the sea often precedes these revolving storms, and always shows they are at no great distance.* The best and surest of all warnings will, however, be found in the barometer; which within the tropics varies so slightly under ordinary circumstances that any fall greater than one-tenth of an inch is a sure sign of an atmospheric disturbance; but in more temperate latitudes, where the barometer varies considerably with no apparent atmospheric change, the indications are less certain.†

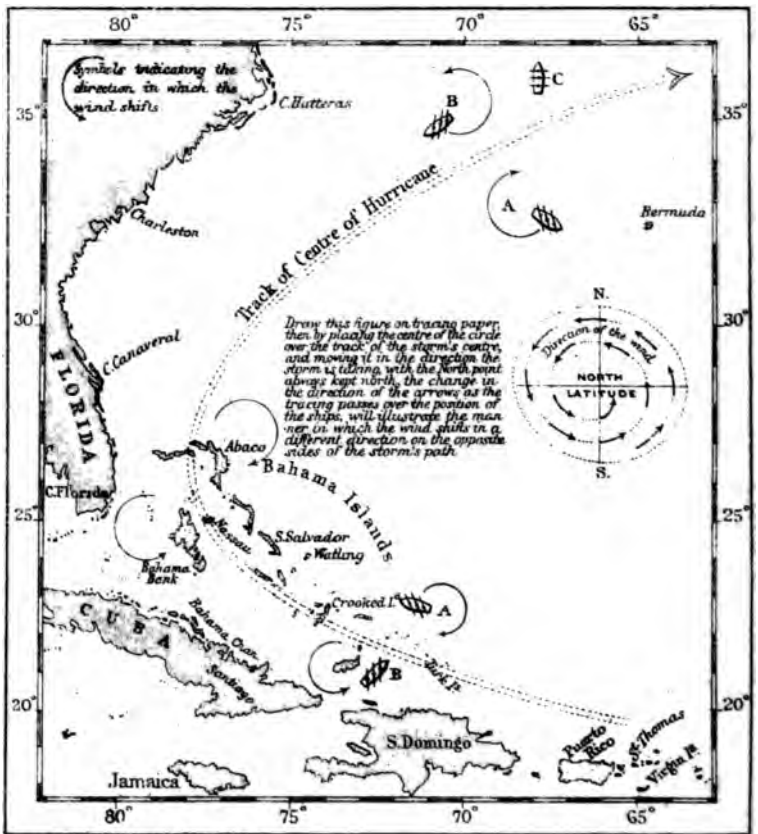
To make use of the slight fall of the barometer mentioned, the seaman should know that the barometer in the tropics has four diurnal oscillations, which are regular in settled weather. The mercury is highest at 10^h a.m. and 10^h p.m., and lowest at 4^h a.m. and 4^h p.m.; the difference between the heights at 10^h a.m. and 4^h p.m. is usually one-tenth of an inch; and if the barometer did not rise from 4^h a.m. to 10^h a.m., or from 4^h p.m. to 10^h p.m.,

* The Chinese boatmen of Hongkong frequently predict the approach of a Typhoon twenty-four hours before its commencement: they are seldom in error.

† The Aneroid is of great value at such a time, especially at night, for it can be registered with great facility, and being portable, may be watched constantly, when the marine barometer may not be accessible; moreover, its variations occur simultaneously with their causes, showing minute changes, unobservable in the best constructed marine barometers, owing to the pumping of the quicksilver, when the motion of the ship is violent.

Northern Hemisphere.

Track of a West Indian Hurricane.



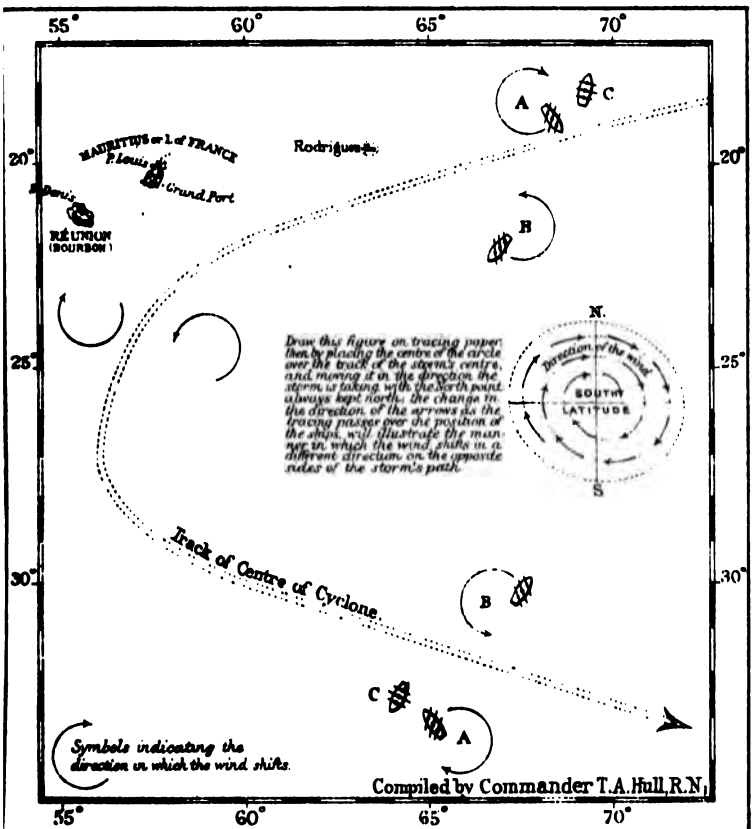
Drawn for the "Sailer's Pocket Book".

A.A.. Ships on the right hand side of the Storm's path, have to on the Starboard tack.
B.B.. Ships on the left hand side of the Storm's path, have to on the Port tack.
C. — Ship running from the Storm's path. *See pages 103 to 108.*

THE LAW OF STORMS.

Southern Hemisphere.

Track of an Indian Ocean Cyclone.


55°
60°
65°
70°
20°
25°
30°
A
C
B
MAURITIUS or I. of FRANCE
P. Louis
Grand Port
Rodrigues
St Denis
RÉUNION
(BOURBON)
Draw this figure on tracing paper; then by placing the centre of the circle over the track of the storm's centre, and moving it in the direction the storm is taking, with the North point always kept north, the change in the direction of the arrows as the tracing passes over the position of the ships, will illustrate the manner in which the wind shifts in a different direction on the opposite sides of the storm's path.
N.
Direction of the wind
SOUTH
LATITUDE
S
Track of Centre of Cyclone
Symbols indicating the direction in which the wind shifts.
Compiled by Commander T.A. Hull, R.N.

Griffin & Cº. Portsea.

A.A.. Ships on the right hand side of the Storm's path, have to on the Starboard tack
B.B.. Ships on the left hand side of the Storm's path, have to on the Port tack.
C.C.. Ships running from the Storm's path. See pages 103 to 108.

the seaman should be on his guard, as in these latitudes the instrument would thus indicate considerable atmospheric disturbance.

If these combined prognostics should occur within the limits of *those regions and seasons* which have been pointed out, let the seaman immediately consider the possibility at least of his being about to encounter a storm of the revolving type.

The first care should be to discover the position of the storm with respect to the vessel. This is readily determined, by noting the direction of the wind when the barometer has fallen about half an inch, as the bearing of the centre generally lies about ten points of the compass from the direction of the wind, but a decided fall of the barometer should take place before the centre is assumed to bear ten points from the direction of the wind.* The rule is then, to face the wind and take the tenth point to the RIGHT—that will be about the bearing to the centre of the storm if in north latitude; or if in south latitude, the tenth point to the LEFT. For example: suppose the vessel to be in lat. 14° N., the wind from the north and the barometer and sky indicating a coming gale,—then, look at the compass, take the tenth point to the right of north, and E.S.E. will be about the bearing of the vortex. Or, if in lat. 14° S., with the wind south, take ten points to the left, and E.N.E. will be about the direction of the centre.

Knowing the bearing of the centre, it is next required to discover on which side of the storm's path the vessel lies. In the Northern Hemisphere, if the ship is on the right-hand side of the path (looking in the direction *towards* which the storm is advancing), the wind veers N., N.E., E., S.E., or with the hands of a watch, whilst if she is on the left-hand side of the path, the wind veers N., N.W., W., S.W., or against the hands of a watch. And in like manner in the Southern Hemisphere, if the ship is on the right-hand side of the path (looking in the direction *towards* which the storm is advancing), the wind veers S., S.W., W., N.W., or with the hands of a watch, whilst if she is on the left-hand side of the path, the wind veers S., S.E., E., N.E., or against the hands of a watch.

In using the above rules it is essential that the ship's position be *as nearly as possible stationary*; for if a ship continues her course the wind may shift in a direction exactly opposite to that which would have been observed had the vessel been stationary, and an erroneous conclusion as to her position in the storm would be drawn. The advisibility of heaving-to on the first approach of a hurricane cannot, therefore, be too strongly urged.

* At a considerable distance from the centre, and before the barometer shall have fallen much, the centre may bear as much as twelve points to the right of the direction of the wind.

The approximate position of storm and probable course of the centre having been thus determined:—

If to the right of the storm's path
In the Northern Hemisphere—Carry-on, or heave-to on *starboard* tack.
In the Southern Hemisphere—Run or heave-to on *starboard* tack.

If to the left of the storm's path
In the Northern Hemisphere—Run, or heave-to on *port* tack.
In the Southern Hemisphere—Carry-on, or heave-to on *port* tack.

As a general rule, it is advisable to HEAVE THE VESSEL TO ON THE TACK ON WHICH SHE WOULD COME UP AS THE WIND SHIFTS.

If, with the ship hove to, the wind continues steady in the same direction, increasing in violence with a rapidly falling barometer, it may be presumed that the ship lies in the direct path of the storm's centre, and it will be necessary to run before the wind, keeping the wind at all hazards two or three points on the starboard quarter in the Northern Hemisphere, or on the port quarter in the Southern Hemisphere.

If the vessel be unable, from want of sea room, to run, her position becomes one of great danger, and every precaution should be taken to prepare for the passage of the centre over the ship; for the steady wind will be succeeded by a short interval of calm, to be followed by a sudden and most violent burst of wind from the opposite point of the compass to that from which the wind has been blowing. After the calm the barometer will commence slowly to rise.

Caution.—In the practical application of the theory of revolving storms, it must be borne in mind that, although the region and season of the year would render the seaman extremely cautious, yet every strong wind or gale met with, especially in extra tropical regions, must not be treated as cyclonic. For example: the master of a vessel running up the Bay of Bengal in the month of May, with S.W. gale, heavy rain, and a falling barometer, must not at once assume that he is in a cyclone.

Similarly, in the neighbourhood of Mauritius, in the months of January or February, with the wind from S.E., steady in the direction, but increasing, accompanied with squalls, rain, and falling barometer—to assume that the vessel is in a hurricane the centre of which bears N.E., and to run to the N.W., would be dangerous. Such a proceeding, in fact, proved fatal to several vessels which, under these circumstances, weighed from Reunion and stood to the N.W. in February, 1860. See *Notes on Cyclones in the Southern Ocean*, by C. Meldrum, M.A., F.R.A.S.

Mr. Meldrum is of opinion that in the Cyclones of the Southern Indian Ocean, "N.E. and easterly winds often, if not always, blow towards the centre of the storm and not at right angles to it."

The barometer must, in these cases, be closely watched, and a decided fall of at least half an inch from the normal average should be experienced before the conclusion is arrived at, that the vessel is within the influence of the cyclone proper.

In either of the above cases the safe proceeding is to *heave-to*, and carefully watch for the shifting of the wind, and the changes of the barometer; then, if the *shifting* of the former and the marked *fall* of the latter prove the gale to be rotating, or cyclonic, the position of the centre and probable direction of its path could be determined with some degree of precision.

Bay of Bengal.—The following information respecting the revolving storms or cyclones of the Bay of Bengal is derived from a report on the Midnapore and Burdwan cyclone of 15th and 16th of October, 1874, by W. G. Willson, Esq.:—

Important distinctions have been observed between the cyclones which visit the shores of Bengal in October and November and those which occur in April and May. The storms of October and November are usually generated in the eastern part of the Bay of Bengal, near or a little north of the Andaman Islands, and although in that locality the formation of the storm is preceded by many days of bad weather, and probably by a low barometer, there are usually no weather indications along the coast line of Bengal of the existence of the coming storm until a day or two before its arrival; and it is not until the place is near the limit of the gale of wind which surrounds the body of the advancing cyclone that any decided fall in the barometer takes place. In the north-west part of the bay during this season north-easterly winds predominate.

The cyclones which are generated in October, somewhere between 14° and 18° N., are those which most frequently visit the shores of Bengal, whilst the storms of November, which are generated further south, are (usually) only felt along the Madras coast.

The cyclones which visit the shores of Bengal in April and May are usually generated in the northern part of the Bay of Bengal; the barometer falls steadily and considerably four or five days previously; S.W. winds prevail during this season, and winds from the N.E. are very unusual. The storms in April and May are not usually so violent as those of October, and seldom travel far inland.

Before a cyclone in the Bay of Bengal, and during its approach, north-

easterly winds prevail over many degrees of longitude to the *north* of the storm, both on the eastern and western side of the path subsequently pursued, and there seems to be no marked tendency of the wind to veer until the cyclone is close at hand. This fact, affecting as it does the generally received rule of allowing ten points to the right of the direction of the wind to determine the bearing of the centre, is important for the seaman to remember; and a decided fall of the barometer should take place before the centre is assumed to bear ten points to the right of the direction of the wind. At a considerable distance from the centre and before the barometer shall have fallen much, the centre may bear as much as twelve points to the right of the wind.

From the foregoing remarks it will (with regard to vessels situated to the northward of the storm's path) be apparent, that whereas in April and May the fall of the barometer and the shift of wind from S. or S.W. to N.E. give timely warning of the approach of a cyclone, yet in October and November the fall of the barometer is usually small, and there is no warning shift of wind if the vessel be to the north of the storm's path.

At the entrance of the river Hooghly the earliest indications of a coming cyclone are probably afforded by the motions of the lower clouds, which drift rapidly by in dark elongated masses from N.E. to S.W., and this is one of the surest tokens of a cyclonic disturbance; these signs are never absent at the Hooghly whenever there is a cyclonic disturbance anywhere in the middle or northern parts of the Bay of Bengal. The mean direction of the wind at the sandheads before a cyclone is always N.E. or E.N.E., more usually the latter when the place is on the track of the storm, but it varies considerably in the gusts, which increase in strength as the storm approaches. The squalls become more frequent, and the driving rain which accompanies them is gradually heavier as the cyclone approaches; a heavy swell comes up from the south-eastward. With such indications, even if the barometer up to the time should have shown no considerable fall, it may be concluded that the cyclone is not very far distant, and it may be expected that the barometer will give less warning of the approach of a storm in October * than in May or June.

The storm wave accompanying the Midnapore and Burdwan cyclone raised the level of the water in Diamond harbour, river Hooghly, sixteen feet.

* The commanders of the pilot brigs stationed off the mouth of the river Hooghly seemed to have misjudged the distance of the Midnapore cyclone (15th October), being probably misled by the slowness of the fall of the barometer.

WEATHER.

Beaufort Notation.

b Blue sky.
c Clouds (detached).
d Drizzling rain.
f Foggy.
g Gloomy.
h Hail.
l Lightning.
m Misty (hazy).
o Overcast.
p Passing showers.
q Squally.
r Rain.
s Snow,
t Thunder.
u Ugly (threatening).
v Visibility {(objects at a distance). {(unusually visible).
w Wet (dew).

A bar (—) under any letter augments its signification; thus $\underline{f}$ very foggy, $\underline{r}$ heavy rain, $\underline{\underline{r}}$ heavy and continuing rain.

GENERAL REMARKS.

Colour of Sky.

A FEW of the more marked signs of weather—useful alike to seaman, farmer, and gardener, are the following:—

Whether clear or cloudy—a rosy sky at sunset presages fine weather; a sickly, greenish hue—wind and rain; tawny, or coppery clouds—wind; a dark (or Indian) red, rain; a red sky in the morning—bad weather, or much wind (perhaps also rain); a grey sky in the morning—fine weather; a high dawn—wind; a low dawn—fair weather.

Soft looking or delicate clouds foretell fine weather, with moderate or light breezes; hard-edged oily looking clouds—wind. A dark, gloomy blue sky is windy; but a light, bright blue sky indicates fine weather. Generally, the softer clouds look, the less wind (but perhaps more rain) may be expected; and the harder, more "greasy," rolled, tufted, or ragged—the stronger the coming wind will prove. Also, a bright yellow sky at sunset presages wind; a pale yellow—wet; orange or copper colour—wind and rain; and thus by the prevalence of red, yellow, green, grey, or other tints, the coming weather may be foretold very nearly—indeed, if aided by instruments, almost exactly.

CLOUDS.

THE scale generally adopted in this country for denoting the amount of cloud is 0 to 10:—0, indicating a clear sky; 5, a sky half covered; and 10, the sky wholly obscured.

Light, delicate, quiet tints or colours, with soft indefinite forms of clouds, indicate and accompany fine weather; but gaudy or unusual hues, with hard definitely outlined clouds, foretell rain, and probably strong wind.

Small inky-looking clouds foretell rain; light scud clouds driving across heavy masses show wind and rain; but if alone, may indicate wind only—proportionate to their motion.

High *upper* clouds crossing the sun, moon, or stars, in a direction different from that of the lower clouds, or the wind then felt below, foretell a change of wind towards *their* direction.

After fine clear weather, the first signs in the sky of a coming change are usually light streaks, curls, wisps, or mottled patches of white distant cloud, which increase and are followed by an overcasting of murky vapour that grows into cloudiness. This appearance, more or less oily or watery, as wind or rain will prevail, is an infallible sign.

Usually the higher and more distant such clouds seem to be, the more gradual, but general, the coming change of weather will prove.

Misty clouds forming, or hanging on heights, show wind and rain coming—if they remain, increase, or descend. If they rise or disperse, the weather will improve, or become fine.

Description of Clouds.

Cirrus cloud consists of streaks, wisps and fibres, vulgarly called "mare's tails," which may increase in any or all directions. Of all clouds it has the least density, the greatest elevation, and the greatest variety of extent and direction or figure.

It remains for a short time when formed in the lower parts of the atmosphere and near other clouds, and longest when alone in the sky, and at a great height. When streaks of cirrus run quite across the sky in the direction in which a light wind happens to blow, the wind will probably soon blow hard but remain steady. When the fine threads of the cirrus appear blown or brushed backward at one end, as if by a wind prevailing in these elevated regions, the wind on the surface will ultimately veer round to that point.

Cumulus, a cloud in dense convex heaps in rounded forms definitely terminated above; the lower surface remains roughly horizontal.

When of moderate height and size, of well-defined curved outline, and appearing only during the heat of the day, they indicate a continuance of fair weather. But when they increase with great rapidity, sink down to the lower parts of the atmosphere, and do not disappear towards evening, *rain* may be expected.

Stratus is a continuous extended sheet of cloud, increasing from below upwards. It is the lowest sort of cloud. It generally forms about sunset, grows denser during the night, and disappears about sunrise.

Cirro-Cumulus is composed of well-defined, small, rounded masses lying near each other, and quite separated by intervals of sky. It is commonly known as a "*mackerel sky*," it occurs frequently in summer, and is attendant on warm and dry weather.

Cirro-Stratus. This cloud partakes partly of the characteristics of the Cirrus and Stratus. In distinguishing it, attention must be paid, not so much to the form, which is very variable, but to the structure, which is dense in the middle and thin towards the edges. It is a precursor of storms; and from its greater or less abundance and permanence, it gives some indication of the time when the storm may be expected.

Cumulo-Stratus. This cloud is formed by the Cirro-Stratus blending with the Cumulus, either among its piled-up heaps, or spreading underneath its base as a horizontal layer of vapour.

Cumulo-Cirro-Stratus or Nimbus. This is the *rain cloud.* At a considerable height a sheet of Cirro-Stratus cloud is spread out, under which Cumulus clouds drift from windward; these rapidly increasing unite at all points, forming one continuous mass, from which rain falls.

Scud. When a rain cloud is seen approaching at a distance, Cirri appear to shoot out from its top in all directions, and it has been observed that the more copious the rainfall, the greater is the number of Cirri thrown out from the cloud.

Rainbows.

"A rainbow in the morning—
Sailors, take warning;
A rainbow at night
Is the sailor's delight."

Morning rainbows indicate the advance of rain cloud from the west when it is clear in the east; and the fall of rain at the time of day when the tem-

perature should be rising, is regarded as a prognostic of a change to wet stormy weather.

On the contrary, the conditions under which a rainbow can appear in the evening are: the passing of the rain cloud to the east, and a clearing up in the west at the time of day when the temperature has begun to fall, thus indicating a change from wet to dry weather.

"The evening grey and the morning red,
Put on your hat, or you'll wet your head."

This does not refer to a *high* red dawn, which may be regarded as a prognostic of settled weather. But if the clouds be red and *lowering* later in the morning, it may be accepted as a sign of rain.

SQUALLS.

GENERALLY squalls are preceded, or accompanied, or followed by clouds; but the very dangerous "white squall" (of the West Indies and other regions) is indicated by a rushing sound, and by white wave-crests.

A squall cloud that can be seen through or under is not likely to bring, or be accompanied by, so much wind as a dark continued cloud extending beyond the horizon.

The rapid or slow rise of a small cloud—its more or less disturbed look,—that is, whether its body is much agitated, and changing form continually, with broken clouds, or scud, flying about—or whether the mass of cloud is shapeless or nearly quiet, though floating onwards across the sky—foretells more or less wind accordingly.

In some of the saws about wind and weather there is so much truth that, though trite and simple, their insertion here can do no harm.

Adverting to the barometer:—

When rise begins, after low,
Squalls expect and clear blow.

Or—

First rise, after low,
Indicates a stronger blow.

Also—

Long foretold, long last:
Short notice, soon past.

To which may be added: In squalls—

When the rain's before the wind,
Halliards, sheets, and braces mind.

And—

When the wind's before the rain,
Soon you may make sail again.

Also generally speaking—

When the glass falls low,
Prepare for a blow;
When it rises high,
Let all your kites fly.

THE BAROMETER.

THE barometer, feeling the pressure of the air, shows at once when that pressure is changing. If the pressure at one place on the earth's surface be greater than at another, the air has a tendency to move from the place where the pressure is greater towards that where it is less, and thus *wind* is caused.

A change of weather comes almost always with a change of wind, and the extent of this change of weather depends on the fact of the new wind being warmer or colder, damper or drier, than that which has been blowing. Any conclusions drawn from its movements must be checked by observations of temperature, moisture of the air, present direction and force of wind, and state of the sky, before any correct opinion can be formed as to what may be expected. In general, whenever the level of the mercury continues steady, settled weather may be expected; but when it is unsteady a change must be looked for, and perhaps a gale.

A sudden rise of the barometer is very nearly as bad a sign as a sudden fall, because it shows that atmospherical equilibrium is unsteady. In an ordinary gale the wind often blows hardest when the barometer is just beginning to rise, directly after having been very low.

Besides these rules for the instrument, there is a rule about the way in which the wind changes, which is very important. It is well known to every sailor, and is contained in the following couplet:—

When the wind shifts against the sun,
Trust it not, for back it will run.

The wind usually shifts *with the sun*, *i.e.* from left to right, in the *Northern Hemisphere*. A change in this direction is called *veering*.

Thus an E. wind shifts to W. through S.E., S., and S.W.; and a W. wind shifts to E. through N.W., N., and N.E.

If the wind shifts the opposite way, viz. from W. to S.W., S., and S.E., the change is called *backing*, and it seldom occurs unless when the weather is unsettled.

However, slight changes of wind do not follow this rule exactly; for instance, the wind often shifts from S.W. to S. and back again.

In the *Southern Hemisphere* the motion *with the sun* is, of course, from right to left, and therefore the above rules will necessarily be reversed.

Admiral Fitzroy proposed the following words for barometer scales:—

RISE.	**FALL.**
For	For
North	South
N.W.—N.—E.	S.E.—S.—W.
Dry	Wet
or	or
less	more
Wind.	Wind.
—	—
Except	Except
Wet from	Wet from
North.	North.

Buys-Ballot's Law.

The law connecting barometric pressure with the direction of wind which has been proposed by Professor Buys-Ballot may be stated thus:—If there be a difference between the barometric readings at any two stations, the wind will blow at *right angles* to the line joining these two places, and the observer standing with his back to the wind will have the place where the reading is lowest on the left-hand side in the Northern Hemisphere, but on the right-hand side in the Southern Hemisphere.

Reading the Barometer.

The lower edge of the vernier should be brought exactly on a level with the top of the mercurial column. Great care should be taken to acquire the *habit of reading* with the eye exactly on a level with the top of the mercury,

that is, with the line of sight at right angles to the scale. A piece of white paper placed behind the slit in the tube, so as to reflect the light, assists in setting the vernier accurately.

The mode of reading off may be learned from a study of the following diagrams, in which A B represents part of the scale, and C D the vernier, the lower edge D denoting the top of the mercurial column. The scale is readily understood: B is 29·0 inches, the second line 29·1, and so on. The first thing is to note the scale line just below D, and the next is to find out

Fig. 1.

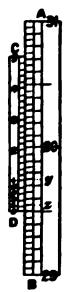
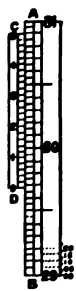


Fig. 2.



the line of the vernier which is in one and the same direction with a line of the scale. In Fig. 1, the lower edge of the vernier, D, is represented in exact coincidence with scale line 29·5; the barometer therefore reads 29·5 inches. Studying it attentively in this position it will be perceived that the vernier line *a* is ·002 inch below the next line of the scale.

If, therefore, the vernier be moved so as to place *a* in a line with *z*, the edge D would read 29·502. In like manner it is seen that *b* is ·004 inch away from the line next above it *on the scale*; *c*, ·006 inch apart from that next above it; *d*, ·008 from that next above it; and 1, on the vernier, is ·01 below *y*. Hence, if 1 be moved into line with *y*, D would read 29·51. Thus the numbers 1, 2, 3, 4, 5, on the vernier, indicate hundredths, and the intermediate lines the even thousandths of an inch. Referring now to Fig. 2, the scale line just below D is 29·65. Looking carefully up the vernier, the first line above the figure 4 is seen to lie evenly with a line on the scale. The number 4 indicates ·04, the first subdivision ·002: and thus we get—

Reading on scale	...	...	29·650
Reading on vernier	...	...	·040 ·002
Actual reading	...	...	29·692 inches.

Sometimes two pairs of lines will appear to be coincident; in which case the intermediate thousandth of an inch should be set down as the reading. Thus, suppose the reading appears to be 29·692 or 29·694, the mean 29·693 should be adopted.

No reading from a barometer which is not hanging truly vertically should ever be recorded.

Range of the Barometer.—The average range of the barometer in the higher latitudes (60°—50°) is about 1·5 inch, but on extraordinary occasions ranges of 2·75 and 3 inches have been recorded.

In the intertropical regions the range varies from 0·4 to 0·2 inch, and in the neighbourhood of the Equator it seldom exceeds 0·15 inch, this small change being due in great part to a regular diurnal variation. The average movement of the barometer within the tropics, being thus confined within small limits, any interruption to the law may be deemed a warning of the approach of bad weather.*

The fall of the barometer in hurricanes ranges from 1·0 to 2·0, and even 2·5 inches, the rapidity of the fall and the depression of the mercury increases as the centre of the storm approaches.

THE ANEROID.

IN the aneroid, atmospherical pressure is measured by its effect in altering the shape of a small, hermetically sealed, metallic box, from which almost all the air has been withdrawn, and which is kept from collapsing by a spring. When atmospherical pressure rises above the amount which was recorded when the instrument was made, the top is forced inwards, and *vice versâ*; when pressure falls below that amount the top is forced outwards by the spring. These motions are transferred by a system of levers and springs to a hand, which moves on a dial like that of a wheel barometer.

This instrument is very sensitive, showing minute changes that are concealed by the pumping of the quicksilver even in the best constructed marine barometers, when the motion of the ship is violent. The Aneroid can be registered with great facility, and being portable, may be watched constantly when the marine barometer may not be accessible; nevertheless, it should, when opportunity offers, be compared with a good mercurial barometer.

* For the lines of equal barometric pressure for the world, see the Wind Charts for the Pacific, Atlantic, and Indian Oceans, published by the Hydrographic Office, 1872.

NORTH ATLANTIC OCEAN.

Mean Barometric Pressure reduced to 32° Fahrenheit.*

	Latitude.	Jan. In.	Feb. In.	March. In.	April. In.	May. In.	June. In.
For Eastern half or to 40th Meridian.	50° to 45°	30·15	30·12	29·90	29·96	29·94	30·00
	45 - 40	30·16	30·12	30·10	30·01	30·02	30·05
	40 - 35	30·18	30·07	30·12	30·06	30·07	30·20
	35 - 30	30·22	30·14	30·10	30·16	30·12	30·20
	30 - 25	30·17	30·23	30·13	30·17	30·22	30·23
	25 - 20	30·10	30·11	30·10	30·10	30·14	30·16
	20 - 15	30·01	30·06	30·04	30·00	30·06	30·03
	15 - 10	29·95	29·97	29·96	29·97	29·99	29·96
	10 - 5	29·90	29·94	29·91	29·92	29·94	29·94
	5 - 0	29·88	29·91	29·89	29·90	29·92	29·93

	Latitude.	July. In.	August. In.	Sept. In.	Oct. In.	Nov. In.	Dec. In.
For Eastern half or to 40th Meridian.	50° to 45°	30·03	30·03	30·00	29·93	30·07	30·06
	45 - 40	30·17	30·10	30·04	30·01	29·98	30·03
	40 - 35	30·19	30·16	30·11	30·09	30·02	30·06
	35 - 30	30·24	30·19	30·15	30·18	30·03	30·18
	30 - 25	30·19	30·16	30·10	30·14	30·06	30·18
	25 - 20	30·09	30·07	30·32	30·07	30·01	30·06
	20 - 15	30·00	30·00	29·99	29·99	29·98	30·01
	15 - 10	29·97	29·93	29·93	29·95	29·96	29·96
	10 - 5	29·98	29·97	29·95	29·93	29·94	29·91
	5 - 0	29·98	29·97	29·98	29·95	29·92	29·91

In the Northern Hemisphere the effect of the veering of the wind on the barometer is according to the following law :—

With East, S.E. South Winds...Barometer falls.

,, S.W. ,, ,, ceases to fall, begins to rise.

,, West, N.W. North ,, ,, rises.

,, N.E. ,, ,, ceases to rise, begins to fall.

* This table, being reduced to 32° Fahr., must be corrected for use by annexed table :—

Temp. of air.	Correction.	Temp. of air.	Correction.
30°	+ 0·018	70°	+ 0·111
40	0·031	80	0·138
50	0·058	90	0·164
60	0·085		

SOUTH ATLANTIC OCEAN.

Mean Barometric Pressure, reduced to 32° Fahrenheit.*

Latitude	Jan. In.	Feb. In.	March In.	April In.	May In.	June In.
0° to 5°	29·89	29·91	29·90	29·92	29·94	29·94
5 - 10	29·95	29·94	29·94	29·94	30·04	30·05
10 - 15	29·97	29·98	29·96	29·99	30·04	30·05
15 - 20	30·02	30·01	30·01	30·03	30·09	30·09
20 - 25	30·06	30·05	30·07	30·05	30·06	30·14
25 - 30	30·07	30·05	30·06	30·03	30·14	30·09
30 - 35	30·05	30·05	30.04	30·03	30·10	30·04
35 - 40	29·98	30·04	30·02	29·98	29·90	29·90
40 - 45	29·92	29·95	29·99	29·95	29·88	29·89
45 - 50	29·71	29·78	29·77	29·76	29·72	29·65
50 - 55	29·41	29·44	29·49	29·44	29·41	29·48
55 - 60	29·25	29·23	29·25	29·20	29 26	29·28

Latitude	July In.	August In.	Sept. In.	Oct. In.	Nov. In.	Dec. In.
0° to 5°	29·99	30·00	30·01	29·96	29·94	29·93
5 - 10	30·02	30·03	30·03	30·02	29·99	29·96
10 - 15	30·05	30·06	30·09	30·07	30·04	30·00
15 - 20	30·09	30·13	30·11	30·10	30·05	30·05
20 - 25	30·11	30·16	30·17	30·18	30·08	30·08
25 - 30	30·13	30·18	30·13	30·16	30·08	30·08
30 - 35	30·12	30·10	30·10	30·08	30·09	30·00
35 - 40	30·04	29·94	29·94	30·05	30·05	29·97
40 - 45	29·95	29·93	29·96	30·02	29·94	29·95
45 - 50	29·82	29·83	29·87	29·77	29·70	29·67
50 - 55	29·53	29·56	29·57	29·48	29·31	29·43
55 - 60	29·25	29.28	29·29	29·10	29·11	29·21

In the Southern Hemisphere, the effect of the veering of the wind on the Barometer is according to the following law :—

With East, N.E. North Winds...Barometer falls.
" N.W. " " ceases to fall, begins to rise.
" West, S.W. " " rises.
" S.E. " " ceases to rise, begins to fall.

* This table, being reduced to 32° Fahr., must be corrected for use by annexed table :—

Temp. of air.	Correction.	Temp. of air.	Correction.
35°	+ 0·018	70°	+ 0·111
40	0·031	80	0·138
50	0·058	90	0·164
60	0·085		

BAROMETER.

Table for converting Millimètres into English Inches.

Mill.	Inches.	Mill.	Inches.	Mill.	Inches.	Mill.	Inches.
712	28·032	731	28·780	750	29·528	769	30·276
3	·071	2	·819	1	·568	770	·316
4	·111	3	·859	2	·607	1	·355
5	·150	4	·898	3	·646	2	·394
6	·190	5	·938	4	·686	3	·434
7	·229	6	28·977	5	·725	4	·473
8	·268	7	29·016	6	·764	5	·512
9	·308	8	·056	7	·804	6	·552
720	28·347	9	·095	8	·843	7	·591
1	·386	740	29·134	9	·882	8	·631
2	·426	1	·174	760	·922	9	·670
3	·465	2	·213	1	29·961	780	30·709
4	·505	3	·253	2	30·001	1	·749
5	·544	4	·292	3	·040	2	·788
6	·583	5	·331	4	·079	3	·827
7	·623	6	·371	5	·119	4	·867
8	·662	7	·410	6	·158	5	·906
9	·701	8	·449	7	·197	6	·945
730	28·741	749	29·489	768	30·237	787	30·985

BAROMETER.

Table for converting English Inches into Millimetres.

Inches.	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09	Inches.
	Mill.	Mill.	Mill.	Mill.	Mill.	Mill.	Mill.	Mill.	Mill.	Mill.	
28·0	711·2	711·4	711·7	712·0	712 2	712·5	712·7	713·0	713·2	713·5	28·0
·1	13·7	14·0	14·2	14·5	14·7	15·0	15·3	15·5	15·8	16·0	·1
·2	16·3	16·5	16·8	17·0	17·3	17·5	17·8	18·0	18·3	18·6	·2
·3	18·8	19·1	19·3	19·6	19·8	20·1	20·3	20·6	20·8	21·1	·3
·4	21·3	21·6	21·9	22·1	22·4	22·6	22·9	23·1	23·4	23·6	·4
·5	23·9	24·1	24·4	24·7	24·0	25·2	25·4	25·7	25·9	26·2	·5
·6	26·4	26·7	26·9	27·2	27·4	27·7	28·0	28·2	28·5	28·7	·6
·7	29·0	29·2	29·5	29·7	30·0	30·2	30·5	30·7	31·0	31·3	·7
·8	31·5	31·8	32·2	32·3	32·5	32·8	33·0	33·3	33·5	33·8	·8
·9	34·0	34·3	34·6	34·8	35·1	35·3	35·6	35·8	36·1	36·3	·9
29·0	736·6	736·8	737·1	737·4	737·6	737·9	738·1	738·4	738·6	738·9	29·0
·1	39·1	39·4	39·6	39·9	40·1	40·4	40·7	40·9	41·2	41·4	·1
·2	41·7	41·9	42·2	42·4	42·7	42·9	43·2	43·4	43·7	44·0	·2
·3	44·2	44·5	44·7	45·0	45·2	45·5	45·7	46·0	46·2	46·5	·3
·4	46·7	47·0	47·3	47·5	47·8	48·0	48·3	48·5	48·8	49·0	·4
·5	49·3	49·5	49·8	50·1	50·3	50·6	50·8	51·1	51·3	51·6	·5
·6	51·8	52·1	52·3	52·6	52·8	53·1	53·4	53·6	53·9	54·1	·6
·7	54·4	54·6	54·9	55·1	55·4	55·6	55·9	56·1	56·4	56·7	·7
·8	56·9	57·2	57·4	57·7	57·9	58·2	58·4	58·7	58·9	59·2	·8
·9	59·4	59·7	60·0	60·2	60·5	60·7	61·0	61·2	61·5	61·7	·9
30·0	762·0	762·2	762·5	762·8	763·0	763·3	763·5	763·8	764·0	764·3	30·0
·1	64·5	64·8	65·0	65.3	65·5	65·8	66·1	66·3	66·6	66·8	·1
·2	67·1	67·3	67·6	67·8	68·1	68·3	68·6	68·8	69·1	69·4	·2
·3	69·6	69·9	70·1	70·4	70·6	70·9	71·1	71·4	71·6	71·9	·3
·4	72·1	72·4	72·7	72·9	73·2	73·4	73·7	73·9	74·2	74·4	·4
·5	74·7	74·9	75·2	75·5	75·7	76·0	76·2	76·5	76·7	77·0	·5
·6	77·2	77·5	77·7	78·0	78·2	78·5	78·8	79·0	79·3	79·5	·6
·7	79·8	80·0	80·3	80·5	80·8	81·0	81·3	81·5	81·8	82·1	·7
·8	82·3	82·6	82·8	83·1	83·3	83·6	83·8	84·1	84·3	84·6	·8
30·9	784·8	785·1	785·4	785·4	785·9	786·1	786·4	786·6	786·9	787·1	30·9
	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09	

THE THERMOMETER.

As the barometer shows weight or pressure of the air, so the thermometer shows heat and cold, or temperature.

The result of numerous observations shows, that in the NORTHERN HEMISPHERE:—

The thermometer rises with E., S.E., and S. winds; with a S.W. wind it ceases to rise and begins to fall; it falls with W., N.W., and N. winds; and with a N.E. wind it ceases to fall and begins to rise.

And in the SOUTHERN HEMISPHERE:—

The thermometer rises with E., N.E., and N. winds; with a N.W. wind it ceases to rise and begins to fall; it falls with W., S.W., and S. winds; and with a S.E. wind it ceases to fall and begins to rise.*

Besides the use of the thermometer, in conjunction with the barometer, in foretelling the changes of weather, the seaman, by its aid, may frequently derive information when passing from one ocean current to another; it also may give warning of the vicinity of Ice.

Fahrenheit's thermometer is generally used in this country, and Réaumur's and the Centigrade abroad. There are disadvantages in the scales of Réaumur and Centigrade, as the length of each degree is much greater than in Fahrenheit, and not so easily nor accurately read when the mercury is between the lines of division; and the temperatures requiring to be registered being often below the freezing of water, are always obliged to be expressed by negative signs.

* These remarks must be considered as relating to the hemispheres generally; there will be local exceptions to these rules: for instance, on the south and west coasts of Great Britain and Ireland, south-westerly winds cause the thermometer to rise.

The different scales are easily convertible by the following rules:—*

Centigrade to *Fahrenheit.* Multiply by 9, divide by 5, and add 32.

$$\frac{9}{5}\text{ C.} + 32° = \text{F.}, \text{ or } 100° \times 9 = 900 \div 5 = 180 + 32 = 212° \text{ Fahr.}$$

Réaumur to *Fahrenheit.* Multiply by 9, divide by 4, and add 32.

$$\frac{9}{4}\text{ R.} + 32° = \text{F.}, \text{ or } 80° \times 9 = 720 \div 4 = 180 + 32 = 212° \text{ Fahr.}$$

Fahrenheit to *Centigrade.* Subtract 32, multiply by 5, and divide by 9.*

$$(\text{F.} - 32°)\frac{5}{9} = \text{C.}, \text{ or } 212° - 32 = 180 \times 5 = 900 \div 9 = 100° \text{ Cent.}$$

Fahrenheit to *Réaumur.* Subtract 32, multiply by 4, and divide by 9.

$$(\text{F.} - 32°)\frac{4}{9} = \text{R.}, \text{ or } 212° - 32 = 180 \times 4 = 720 \div 9 = 80° \text{ Réaum.}$$

Centigrade to *Réaumur.* Multiply by 4, and divide by 5.

$$\frac{4}{5}\text{ C.} = \text{R.}, \text{ or } 100° \times 4 = 400 \div 5 = 80° \text{ Réaum.}$$

Réaumur to *Centigrade.* Multiply by 5, and divide by 4.

$$\frac{5}{4}\text{R.} = \text{C.}, \text{ or } 80° \times 5 = 400 \div 4 = 100° \text{ Cent.}$$

* When Fahrenheit is between zero and 32°, it must be remembered that the values of Réaumur and Centigrade are negative, and express the required number of degrees *below* zero on Réaumur's and the Centigrade scale.

Comparison of the Fahrenheit, Centigrade, and Réaumur Thermometers.

Fahr.	Cent.	Réaum.	Fahr.	Cent.	Réaum.	Fahr.	Cent.	Réaum.
	°	°	°	°	°	°	°	°
1	- 17·2	- 13·8	35	1·7	1·3	69	20·6	16·4
2	16·7	13·3	36	2·2	1·8	70	21·1	16 9
3	16·1	12·9	37	2·8	2·2	71	21·7	17·3
4	15·6	12·4	38	3·3	2·7	72	22·2	17·8
5	15·0	12·0	39	3·9	3·1	73	22·8	18·2
6	14·4	11·6	40	4·4	3·6	74	23·3	18·7
7	13·9	11·1	41	5·0	4·0	75	23·9	19·1
8	13·3	10·7	42	5·6	4·4	76	24·4	19·6
9	12·8	10·2	43	6·1	4·9	77	25·0	20·0
10	12·2	9·8	44	6·7	5·3	78	25·6	20·4
11	11·7	9·3	45	7·2	5·8	79	26·1	20·9
12	11·1	8·9	46	7·8	6·2	80	26·7	21·3
13	10·6	8·4	47	8·3	6·7	81	27·2	21·8
14	10·0	8·0	48	8·9	7·1	82	27·8	22·2
15	9·4	7·6	49	9·4	7·6	83	28·3	22·7
16	8·9	7·1	50	10·0	8·0	84	28·9	23·1
17	8·3	6·7	51	10·6	8·4	85	29·4	23·6
18	7·8	6·2	52	11·1	8·9	86	30·0	24·0
19	7·2	5·8	53	11·7	9·3	87	30·6	24·4
20	6·7	5·3	54	12·2	9·8	88	31·1	24·9
21	6·1	4·9	55	12·8	10·2	89	31·7	25·3
22	5·6	4·4	56	13·3	10·7	90	32·2	25·8
23	5·0	4·0	57	13·9	11·1	91	32·8	26·2
24	4·4	3·6	58	14·4	11·6	92	33·3	26·7
25	3·9	3·1	59	15·0	12·0	93	33·9	27·1
26	3·3	2·7	60	15·6	12·4	94	34·4	27·6
27	2·8	2·2	61	16·1	12·9	95	35·0	28·0
28	2·2	1·8	62	16·7	13·3	96	35·6	28·4
29	1·7	1·3	63	17·2	13·8	97	36·1	28·9
30	1·1	0·9	64	17·8	14·2	98	36·7	29·3
31	0·6	0·4	65	18·3	14·7	99	37·2	29·8
32	0·0	0·0	66	18·9	15·1	100	37·8	30·2
33	+ 0·6	+ 0·4	67	19·4	15·6			
34	1·1	0·9	68	20·0	16·0			

CURRENTS.

THE Currents of the ocean are properly distinguished by the different and significant names—STREAM and DRIFT.

The Drift Current is merely the effect of the wind on the surface of the water; as, for example, in the region of the Trade winds, where the whole surface of the sea (generally speaking) is converted into a slow current moving to leeward. A drift current is, therefore, shallow and slow, and can run in no other direction than to leeward.

The Stream Current has been described as an accumulation of the parts of the drift into a collective mass by the intervention of some obstacle; the mass then running off by means of its own gravity, and taking the direction imposed on it by the obstacle, becomes a stream of current, and in many cases a powerful stream, pursuing its way like a vast river through the ocean.

These "oceanic rivers" may vary in breadth like the Gulf Stream, from 50 to 250 miles; and are sufficiently deep to be turned aside by banks which do not rise within 60 or 80 fathoms of the surface—as the Agulhas current is deflected by the Agulhas bank off the Cape of Good Hope—and run with such rapidity as to be uninfluenced materially by the wind, except near their borders.

Changes of temperature of the surface water are frequently abrupt. These changes are especially marked on the edges of stream currents, as, for example, on the north and west edges of the Gulf Stream, where it is met by the Labrador current from Davis Strait, and the two streams run nearly side by side; also off the Cape of Good Hope, at the junction of the Agulhas current and the cold water flowing into low latitudes from the Antarctic Sea; and again off the east coast of South America, south of Rio de la Plata, where the Brazil current is met by the cold stream from Cape Horn.

Caution.—It is especially to be observed that the seamen must be prepared for unsettled weather, and a cross and often turbulent sea, when passing *through* alternating bands of warm and cold water.

The Currents of the Atlantic Ocean.

THE ARCTIC OR LABRADOR .....Cold.
THE GULF STREAM .....Warm.
THE N.E. TRADE DRIFT .....
THE GUINEA CURRENT .....Warm.
THE EQUATORIAL CURRENT .....Cold at the beginning.
THE EQUATORIAL COUNTER CURRENT .....Warm.
THE BRAZIL CURRENT .....Warm.
THE CAPE HORN CURRENT .....Cold.

A general set to the northward from the Antarctic regions.

The Arctic or Labrador Current sets from Smith Sound through Baffin Bay and Davis Strait, and then forms a broad stream running parallel to the coast of Labrador; its eastern limit being in about lat. 50° N., and long. 42° W. From the parallel of 50° N. the current turns to the south and south-west, running over the Banks of Newfoundland and then forming the cold stream that sets along the American shores, between the Gulf Stream and the land. This current brings with it the large quantity of field ice and icebergs that are found in the neighbourhood of Newfoundland. On first meeting with the Gulf Stream a portion of the Labrador current setting to the southward, becomes an under current, carrying field ice and icebergs into the warm water. Icebergs have been taken by this means as far south as the parallel of 38° N.

The Gulf Stream.—This remarkable "ocean river" issues with great velocity, and in great volume from a sea of unusually high temperature, and deposits a vast body of warm water in the central part of the North Atlantic Ocean; a warmer region of the atmosphere is thus formed in the midst of a colder one, across two-thirds of the Atlantic, between the parallels of 35° and 45°.

The water of the Gulf Stream is a deep indigo blue in colour, and its junction with ordinary sea water distinctly marked. In moderate weather the edges are marked also by ripplings, and, in the higher latitudes, frequently by evaporation. At the surface—especially so off the coast of the United States were it meets the cold polar current—it is divided into several bands of higher and lower temperature, of which the axis of the stream, or line of greatest velocity is the hottest; the temperature of the water falling rapidly in shore, and more slowly outside this line; the same features are observed in a modified form at considerable depths.

Between the axis of the stream and the coast, the fall of temperature is so sudden that the line of separation has received the distinctive name of the "cold wall;" a difference of 30° at the surface having been here observed within a cable's length. The presence of warm water is, however, not always an indication that a vessel is under the influence of the easterly current, as the Gulf Stream, like a swollen river, frequently overflows its banks, and a counter current of the returning warm water prevails; hence the westerly and south-westerly currents so often experienced to the southward and eastward of the Gulf Stream.

The warm water limits are very variable, as are also, in a lesser degree, those of the stream, for N.E. and S.E. gales force the latter to the banks skirting the American shores, whilst N.W. and westerly gales drive the stream from the shores, so that the anomaly of the stream running in cold water and its absence in the warm water has been observed.

The velocity of the Gulf Stream varies with the seasons, running strongest in July, August, and September. On entering Florida Strait, from the Gulf of Mexico, the general rate is from two and a half to four miles an hour; in the narrows of the Straits five miles an hour has been observed in August; beyond this, to the parallel of 35°, the rate is about three and a half miles, gradually decreasing as the stream expands to the N.E.; although, even near the meridian of 45° W. on the 43rd parallel, the exceptional rate of four miles an hour in August has been recorded. Eastward of 35° W. it becomes the great north-easterly surface drift, that is felt as far as the coast of Norway.

On issuing from the Gulf of Mexico the stream has a maximum temperature of 85°, or 5° to 6° above the ocean temperature due to that latitude; and off the banks of Newfoundland is higher by 20° or 30° than the adjoining ocean. The following table gives the average temperature in the axis of the stream, or warmest band of water;—

	January.	April.	July.	October.
FLORIDA STRAIT ...	... 77°	... 78°	... 83°	... 82°
OFF CHARLESTON ...	... 75	... 77	... 82	... 81
OFF CAPE HATTERAS	... 72	... 73	... 80	... 76
S.E. OF NANTUCKET SHOALS	67	... 88	... 80	... 72
SOUTH OF NOVA SCOTIA ...	62	... 67	... 78	... 69

The weather in the Gulf Stream is warm, squally, and unsettled, and with S.W. or W. gales the air is sultry. Beyond its north and west limits the weather is extremely cold. The sea in bad weather is heavy and irregular.

The evidence of the old navigators is against taking the advantage of the *favour*able set of the Gulf Stream on the voyage from the West Indies to

Europe; they deemed this route ill-judged, as not compensating for the wear and tear of the rough weather experienced; and adopted, in preference, one south of the 33rd parallel, as the great storms were considered to happen to the north of 32° and 33°. The Admiralty Pilot Charts of this region show during the year one hundred and twelve gales between the parallel of 35° and 40°, against sixty-three gales between the parallels of 35° and 30°.

The Guinea Current.—The Drift current setting to the southward along the west coast of Africa between Cape Spartel and Cape Verde, becomes after passing the latter promontory a stream current, running to the eastward, along that part of the African coast comprised chiefly between Cape Roxo and the Bight of Biafra, extending southward to the 3rd and 2nd parallels of north latitude. Its western limit can be traced at all seasons of the year as far as the 23rd meridian of west longitude.

The greatest velocity of the Guinea current is stated to be off Cape Palmas, where at a few miles from the shore it has been found to run more than three knots an hour. The space separating this current from the Equatorial is generally limited, thus presenting the remarkable feature of two well-marked streams running in exactly opposite directions side by side.

The Guinea current proper may be considered a warmer stream than the Equatorial at all seasons, but careful observations on this head are yet wanting.

For about two hundred miles from the coast, between Cape Verde and Sierra Leone, winds and currents change with seasons. From June to September squally S.W. winds prevail, with a N.E. or northerly current. From October to May, when N.E. and northerly winds prevail, a south-easterly current is experienced.

Between Sierra Leone and Cape Palmas, the current is influenced by the wind. Between May and October the current runs to the N.W. with winds south of S.W.; and S.E. with winds west of S.W. In November it generally sets to the N.W., while from December to May a S.E. current is experienced.

In the Harmattan season (December to February) the Guinea current near the land is checked, and in shore a westerly set is found. Heavy tornados have a similar effect.

The Equatorial Current.—The Drift current setting to the northward along the African coast between St. Helena bay and the river Congo, forms after passing that river the Equatorial current, which, in its course between

the continent of Africa and America, becomes a stream current formed of water brought from a cooler region by the prevailing southerly winds.*

This great stream sets from east to west across the Atlantic, towards the north coast of Brazil, and along the coast of Guiana; running with a velocity of two and a half to three miles an hour, increasing in strength as it advances to the westward. When about 300 miles from Cape St. Roque this current divides, the main part running along the north coast of South America towards the West Indies, while a large portion branches off to the S.W., and setting along the east coast of South America, forms the Brazil current.

Entering the Caribbean Sea through the Gulf of Paria and to the N.E. of Trinidad, between the various islands as far north as Martinique, the Equatorial current runs first westerly and then north-westerly towards Cape Catoche in Yucatan, a small portion being deflected off that cape towards the island of Cuba. The main stream flows round the Yucatan bank, and following the shores of the Gulf of Mexico meets off Cape Florida the stream setting from the Atlantic Ocean along the northern shores of the Greater Antilles. These united currents setting first to the northward between the coast of Florida and the Bahamas Islands, next run to the N.E. into the North Atlantic Ocean, and form the well-known Gulf Stream.

The direction and strength of the Equatorial current undergoes various changes in its course through the West Indian islands, and along the coasts of Central America. Powerful eddies, with counter streams, will often be experienced, although the general movement will be continued. An easterly current is at times met with along the southern shores of the Greater Antilles. Between Haiti and Cuba the general direction of the stream is S.W.

The Equatorial current appears to attain its greatest volume and velocity during the season of the northern summer. From the African coast to about the 15th degree of west longitude, the maximum strength has been observed in June and July; westward of that meridian at successive later periods, or between July and October.

The northern boundary, or rather the well-marked line of separation between it and the Guinea current, has been well traced in the space extending from the meridian of Greenwich to 23° W., and is found to vary little at

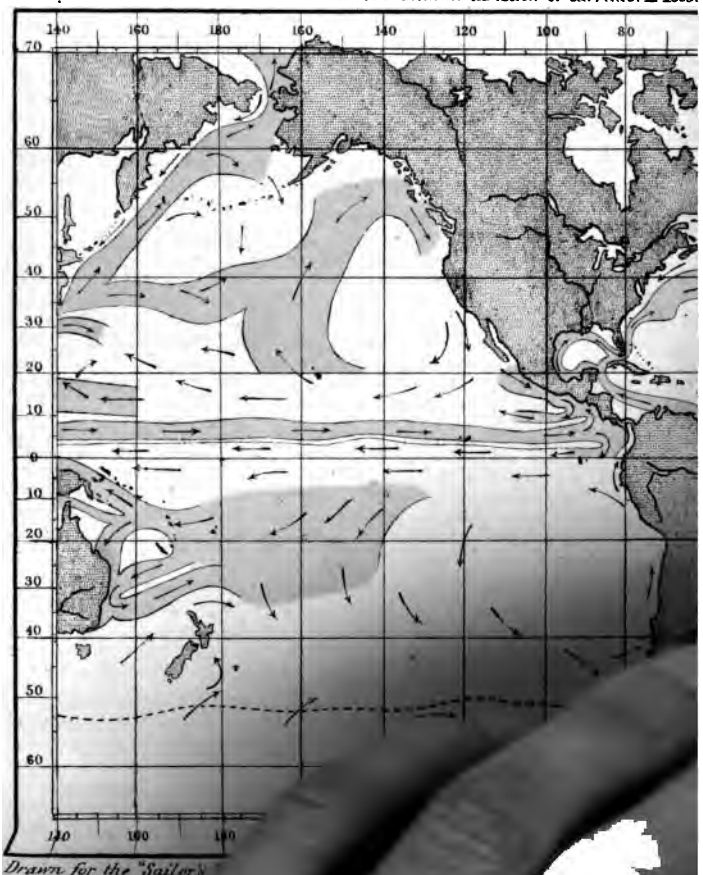
* The stream of the river Congo is occasionally felt three hundred miles from the entrance, and the discoloration of the ocean perceptible. It runs with almost undeviating regularity to the N.W. and N.N.W., decreasing in strength as it extends seaward; its rate is *about* two miles an hour until absorbed in the Equatorial current.

CU

Compiled by Commander Thom

See Pages 124 to 140.

Arrows indicate direction of Currents.—Iceb



HART.

eSuperintendent of Admiralty Charts.

thus_____ — Warm Currents, coloured Red

Griffin & Co. Portsea.

the several seasons of the year. For example, in long. 20° W. the "line of separation" in October and November is in 5° N., in March and April in 2½° N.; in the 5th degree of west longitude, the "line of separation" appears to be generally constant in 2° N. Approaching the African coast, Anno Bom Island is considered to be at all seasons in the Equatorial current; Princes Island in the Guinea current; and St. Thomas, situated nearly midway between the two, as within the influence of one or the other current according to the seasons.

The surface temperature in the eastern part of the Equatorial current is several degrees colder for a great part of the year than the adjacent Guinea current, affording evidence of receiving waters from a remote and colder parallel. From Anno Bom Island to about long. 15° W., the following are the average surface temperatures of the Equatorial current:—

December to March,	78° to 82°.	March to July .	82° to 72°.
July to October .	72° to 75°.	October to December,	75° to 78°.

Westward of the 15th Meridian, the surface temperatures at the several seasons lessen materially in their range, and the Equatorial current gradually loses its earlier features of being a cold water stream at one particular season of the year.

The Equatorial Counter Current.—Between the months of July and November, the northern edge of the Equatorial current, in lat. 8° to 10° N., and near the long. of 53° to 50° W., appears to recurve, changing its direction to N. and N.E., and finally setting to the eastward towards the coast of Africa. This current increases in breadth and velocity as it advances to the eastward. Between 50° and 40° W., it attains a rate of sixty miles a day; eastward of 40° it decreases in strength; and between 30° and 20° W., it runs from thirty to fifteen miles a day.

North Coast of Brazil and Coast of Guiana.—The current runs along this part of South America, on its way towards the West Indies. The rate may vary from half a mile to four miles an hour, according to the distance from middle of the stream and season of the year; it probably attains its greatest strength at 100 or 120 miles from the coast. This stream is about 200 miles wide, the inner edge varying from 15 to 45 miles from the coast. Within a few miles of the coast tidal streams are perceptible. During the prevalence of N.E. winds a current runs E.S.E., along and near the north coast of Brazil; this fact is well known to the masters of the coasters.

River Amazon.—The waters of the Amazon attain their highest elevation in May, after a gradual rising of six months' duration; and then

gradually fall six months. The stream from the Amazon (the ebb) at first sets E.N.E., then inclines to N. and N.W., as it unites with the Equatorial current; increasing the velocity of the latter. The surface of the ocean is discoloured by the waters of the Amazon for a considerable distance to the northward and westward of the mouth of that river. Off Cape North, the stream of flood into the Amazon runs with double the strength of the ebb between January and April; in May, the flood and ebb streams are equal; from July to October the ebb has the greater strength; from November to January the two streams are again equal.

The Brazil Current is a branch of the Equatorial, setting, at a rate of 25 to 30 miles a day, along the coast of the South American continent as far as the islands of Trinidad and Martin Vaz, where it divides: one part, curving to the S.E. and E., forms the Connecting current of the South Atlantic; the other branch, flowing to the S.W., forms a feeble current, felt as far south as the 45th parallel.

For about 150 miles from the Brazilian coast, between the parallel of 10° S. and Cape Frio, the current is influenced by the wind. Between October and January it generally sets to the S.W., at the rate of 25 to 30 miles a day; between March and September it sets to the northward, running strong in July, when it occasionally attains a velocity of 48 miles a day.

Off Bahia, and for about 200 miles southward of that port, the current appears to set directly *on to* the coast. Between Cape Frio and the Rio de la Plata south-easterly winds force the water *towards* the shore, causing a heavy sea. In shore, an occasional counter current to the N.E. is experienced.

Rio de la Plata.—The currents of the Rio de la Plata are governed by the winds, the water rising with southerly and falling with northerly winds. Off the entrance they generally set to the N.N.W. before and with southerly winds, and to the S.S.E. before and with northerly, at rates varying from one to three miles an hour. An E. and E.N.E. current of one mile an hour, a supposed outfall from the Rio de la Plata, has been experienced, extending nearly to the 40th meridian.

The Currents of the Indian Ocean.

The currents of this ocean are generally with the monsoons. There is, however, a constant stream setting to the westward past the north end of Madagascar, striking the African coast about Cape Delgado, where it divides; one part trending to the northward, and the other branch flowing southward *along* the African shore of the Mozambique Channel.

During the N.E. Monsoon the northern branch is turned when north of Zanzibar by the current setting out the Arabian sea; the united streams then run to the eastward between the Equator and the parallel of 7° S. In the S.W. Monsoon the same current sets to the north-eastward along the African coast towards the Island of Sokótra.

The Currents in the Arabian Sea in the South-West Monsoon are regular in direction, their velocity depending much on the force of wind and local circumstances. The general course of the current in the middle of the sea is about E., inclining to S.E. as it nears the western coast of India; its velocity varies from half a mile to two miles per hour.

On the eastern coast of Africa the current sets from Zanzibar along the coast to the N.N.E. at a velocity of two to four miles per hour, passes through the channel between Sokótra and the N.E. point of Africa at a rate of one and a half to two miles per hour, pursuing a course northerly and easterly, until it impinges on the Arabian coast about Rás Kosaïr, whence it takes a north-easterly course along that coast to Rás-al-Hadd, at a velocity of half to one and a half miles per hour.

To the south of Sokótra, at a distance of about 150 miles, is a great whirl of current. This eddy commences about the parallel of Rás Hafûn, strikes off to the eastward, as far as the 55th meridian, then turns to the southward, to the 5th parallel, whence it again curves up to the north-eastward. At the northern limit the velocity is very great, being four to five miles per hour, while at its southern extreme it is not more than one mile per hour. A heavy confused sea is created by this whirl. Care should be taken to avoid the strongest portion of the current in making the coast of Africa from the eastward, by keeping well to the southward.

Little is known of the currents at this season close to the northward of Sokótra, but there is said to exist a whirl similar to, but of less magnitude than that south of the island. Horsburgh remarks that the currents on the north side run with the prevailing breezes to the north-eastward; but, when the wind moderates, an almost equally strong current runs in the opposite direction. This most probably applies to within a few miles of the land.

Throughout the S.W. Monsoon, or from June to September inclusive, the waters runs out of the Red Sea, while from November to May the contrary is the case. During the S.W. Monsoon, the current on the Arabian side of the gulf of Aden runs to the eastward as far as Rás Rehmat, or Hisn Ghorab, whence it strikes off to the south-eastward to Rás 'Asir or Cape Guardafui, the N.E. point of Africa; it then turns to the westward, close along the African coast, as far as the 47th meridian, whence it again curves to the

northward. From the Straits of Bab-el-Mandeb the current sets along the African coast to the 47th meridian, where meeting the westerly set from Cape Guardafui, it turns to the N. and N.E. The velocity of the current throughout the Gulf of Aden varies from half a mile to two miles per hour.

In the North-East Monsoon the current in the Arabian Sea runs to the southward along the Malabar coast, and then generally sets to the south-westward, its velocity depending on the force of the wind. On reaching the African shore, this current runs along the coast at the rate of from one and a half to two and a half miles an hour, meeting in about lat. 4° S. the northerly stream from Zanzibar; both streams then turn to the eastward, setting right across the Indian Ocean between the Equator and the parallel of 7° S. There is a general set of from one to two miles an hour to the S.W. along the S.E. coast of Arabia, and into the Gulf of Aden.

The Currents off the South Coast of Ceylon from the month of November, or during the N.E. Monsoon, set S.S.W. out of the Bay of Bengal for five months and a half without variation—running with a velocity of from one to three and a half, and sometimes of five knots an hour—thus, a steamer, steering N.N.E., has not only to oppose a three-knot current, but also has the wind dead against her; some steamers make barely two miles an hour when bound to the northward.

From May to September, or during the S.W. Monsoon, the current runs N.E. and N.N.E., at from one to three knots an hour. During these months, in the event of a vessel making Dondra Head, when bound to Galle, which is not uncommon, the master should never attempt to beat to Galle, but recross the Equator. In the neighbourhood of the Basses reefs a remarkable circumstance occurs with regard to the current during the S.W. Monsoon. After running three knots to the N.E. for ten days, suddenly it slackens, and runs two to three and a half knots S.W., or from the Bay of Bengal, lasting sometimes only one day, at other times for a week; these changes happen at all times of the moon, and appear to obey no recognized law.

Agulhas Current.—An enormous body of warm water running to the southward and westward from the Mozambique channel and Indian Ocean, and known as the Agulhas current, skirts the coast of South Africa approaching the shore between the 30th and 28th meridians of E. longitude. The stream has here an average width of 50 miles, with an occasional velocity of four miles an hour. As it progresses to the S.W., and arrives at the southern side of the Agulhas bank, the main body, in about long. 22° E., is deflected to the southward, and recurves to the eastward, thus flowing back into the *Indian Ocean*—but with diminished strength and temperature—on the parallel

of 40° S., where its influence is felt as far as the islands of St. Paul's and Amsterdam. The cold Antarctic current, setting slowly but persistently from the southward, is frequently found crossing this part of the Agulhas current.

A small portion of current passing over the southern part of the Agulhas bank, and branching off to the N.W., unites with the easterly or "connecting" current of the South Atlantic Ocean, setting towards the Equator, at the rate of about one and a half miles an hour.

The remarkable recurving of the main body of the Agulhas current is due to the action of a polar or cold water current flowing from the S.W., the junction, or intermingling, of the hot and cold waters of the two streams notably taking place off the Agulhas bank, giving rise to the troubled and confused sea, the irregular and uncertain set of the currents, and by their effect on the atmosphere to those severe and fitful gales so well known to seamen rounding the Cape of Good Hope.

From January to March the warm water of the Agulhas current appears to be pushed a considerable distance to the westward (as far as the longitude of about 10° E.); the stream at this time attains its maximum strength and volume. In June, July, and August, the current diminishes in force and extent, and the cold water from the higher latitudes repels and permeates it easily.

Temperature of the Agulhas current in :—

	October.	January.	April.	July.
OFF NATAL	71° ...	76° ...	75° ...	70°
OFF ALGOA BAY	69 ...	74 ...	73 ...	61
S.E. OF AGULHAS BANK ...	65 ...	71 ...	69 ...	65
MERIDIAN OF CAPE AGULHAS ...	63 ...	68 ...	67 ...	61

Bands of warm and cold water are found at all seasons, extending south as far as the 42nd and 44th parallels of latitude; but the space included between the parallels of 36° and 38° S. and the meridians of 22° and 26° E. is that where the violence of the conflicting currents of cold and warm water and cold and warm air appears to be centred.

There is a constant current to the northward along the western shore of Australia, and a general set to the northward into the Indian Ocean from the Antarctic regions.

Currents in the Eastern Passages to China.

The currents in the passages east of Java are various, and have not yet been reduced to any fixed laws. The great irregularities they appear to be subject to is doubtless due to their geographical relations, lying as they do between the wind systems of the northern and southern hemispheres. But as their action is frequently of importance in endeavouring to make a passage against adverse winds, they require much attention. The notes which follow are given as a guide to their general character.

On the South Coast of Java, where the monsoons are liable to great deviations, there are some *remarkable reverse currents* experienced within a degree or two of the coast. During the Easterly Monsoon, April to November, a constant easterly current is encountered running against the monsoon, at times so strong as to ripple, but on an average ten to twelve miles a day. The drift is frequently to the S.E. two-thirds of a mile an hour. Captain M. J. Jansen has, however, stated that in the E. Monsoon the current sets to the westward from full to change of the moon, and either to the eastward from the change, or that there was no current. It is certain that near the shore there is a considerable set to the westward in this monsoon.

In the W. Monsoon, December to April, the current sets sometimes to the S.S.E. and S., decreasing in force between lat. 11° and 15° S., and then ceases, and a strong westerly current is encountered, increasing in velocity as Sunda Strait is approached, amounting at times to 42 miles a day.

In Baly Strait the currents or tides run through the narrows with exceeding velocity—some say six knots—and cause great ripplings, eddies, and a boisterous sea, particularly near the shore of Baly during the S.E. Monsoon, when the S.S.W. winds blow so strongly that it is often impossible to manœuvre a ship. The flood runs to the northward and the ebb to the southward, and it is high water full and change, between 10^h. and 1^h. At neaps the tides are irregular. They change first on the Java side of the strait, and about two hours later on the Baly side. During the E. Monsoon, May to November, the flood is often only found near the Java shore, and even then not to the northward of the strait, but during the W. Monsoon the northerly currents prevail. A tide often lasts for seven or eight hours.

Ombay Passage.—The currents are strong, with great ripplings, in the Ombay Passage and other passages northward of Timor, generally setting to the N.E. during the W. Monsoon, and to the S.W. during the E. Monsoon; but in some places, close in shore, weak tides have been experienced. The *strong* current in the Ombay Passage seems to cause a strong easterly current

along the north coast of Ombay during the E. Monsoon, May to November. In June the S.W. current of Ombay Passage attains its greatest strength, amounting to from 72 to 82 miles in twenty-four hours. In August and September, there are strong easterly currents in Ombay Passage, though in October they often run with great velocity to the south-westward.

Near the entrance of the Straits of Allor and Pantar the current takes a northerly direction during the E. Monsoon, but during the W. Monsoon it sets out S.S.W.

Java to Amboina.—Ships from Java or Macassar bound to Amboina or the Molucca channels during the E. Monsoon work along the north coasts of Sumbawa, Flores, Ombay, etc., till they have reached the N.W. or N. point of Wetta, or farther eastward if bound to Banda, and the voyage is often much accelerated by favourable currents.

Molucca Channels.—During the E. Monsoon, May to November, the current sets to the N.W. along the western coast of New Guinea, and between the Ki and Arrou Islands, and thence westward along the south coast of Ceram, at the rate of one or one and a half miles an hour, according to the strength of the wind, the velocity being greatest along the coast of New Guinea. At the same period an easterly current prevails on the north side of the islands, extending from Timor to Timor Laut, so that a moderately fast vessel would experience no difficulty there in beating up against the monsoon. In the W. Monsoon the current in these seas usually sets with the wind, but its velocity is not so great as during the other season.

New Guinea.—Of the currents on the north coast of New Guinea we have few particulars, and these chiefly from D'Urville, who sailed along it in August, 1827, where he found strong W. and N.W. currents of more than a mile an hour. It is probable that this westerly drift is constant. Later information shows that on reaching the island of Gillolo this current trends first to the northward, and then curving round to the eastward, forms the beginning of the Pacific counter current.

The Currents of the Pacific.

The Aleutian—a cold current setting to the southward through those islands from Behring Sea.

Japan Stream (Kuro Siwo).*—The N.E. Trade drift-current of the Pacific, which flows to the westward between the parellels of 9° N. and 20° N., on reaching the eastern shores of the Philippine Islands is

* Black stream or tide so called from its black appearance.

deflected to the northward, forming in lat. 21° N., between the meridian of 125° E. and the east coast of Formosa, the commencement of the great oceanic current known as the Kuro Siwo, or Japan stream, the limits and velocity of which are considerably influenced by the monsoons of the China Sea and the prevailing winds in the Yellow and Japan seas.

During the North-East Monsoon a part of the Pacific drift-current continues its course to the westward through the Bashee and Balintang channels, joining the monsoon drift-current which sets strong to the south-westward at this season, through the Formosa channel and China Sea.

During the South-West Monsoon the drift-current which flows to northward in the China Sea and Formosa channel, joins the Kuro Siwo, and extends the western limit of its stream to a line joining the island of Tung Ying (on the coast of China) to Tsu-sima (in the Korea Strait); this limit is very perceptible, the waters of the Japan stream being of a dark blue colour, whilst that of the colder water of the coast of China is of a pale green; the difference in temperature of the two streams is also very marked.

The main body of the Kuro Siwo is joined at this season by the monsoon drift-current of the China Sea, which also sets to the N.E. through the Bashee and Balintang channels, and, being augmented in force, flows rapidly to the northward along the east coast of Formosa, passing between the north end of that island and the Meiaco-sima group, as far as the parallel of 26° N., where it turns to the eastward and continues in a north-easterly direction to the westward of the Liu-Kiu Islands until it reaches the southern point of Japan. Here an off-shoot of the main stream passes to the northward through the Korea Strait into the Japan Sea; the main body of the stream, however, continues its course, and trending still more to the eastward, flows in an E.N.E. direction through Van Diemen Strait, the numerous channels between the islands north of the Linschoten group, and along the southern shores of the islands of Kiusiu and Sikok, forming (especially along its margin near the shore, where it meets with an opposing tide) races and tide rips often resembling heavy breakers on reefs or shoals. The Kuro Siwo attains its greatest velocity when abreast of Sikok, where it has been known to set 100 miles in twenty-four hours; its usual velocity in this locality, however, being from two to three knots an hour.

Continuing its course along the south coast of the island of Nipon, past the Gulf of Yedo, the Kuro Siwo flows through the chain of islands lying south of that gulf; in the numerous channels between which its direction is found to be variable and under tidal influence, thus forming many tide rips *and* whirlpools. Continuing in an E.N.E. direction as far as lat. 36½° N.,

the northern edge of the Japan stream then leaves the coast of Nipon (which here trends to the northward from about Inaboye-saki) and runs N.E., while a cold current, setting to the southward along the shores of Kamtchatka and the Kuril Islands, intervenes between the Kuro Siwo and the north-eastern shores of Nipon and Yezo. Continuing to the north-eastward, the Kuro Siwo begins to expand, and diminishes greatly in velocity after passing the meridian of 145° E.

At about the meridian of 150° E, the Kuro Siwo divides, one part flowing to the northward, and, taking the name of the Kamtchatka current, is felt as far as the Aleutian Islands and Behring Strait, whilst the greater portion of the stream continues in an easterly direction, between the parallels of 32° N. and 41° N., as far as the meridian of 160° E., where it curves to the south-eastward to the meridian of 180°, there losing its identity in the drift-currents of the North Pacific Ocean which flow to the N. and N.E.

The maximum temperature of the stream during the S.W. Monsoon is 86°, and its north-western edge is strongly marked by a sudden thermal change in the water of from 12° to 20°; but the southern and eastern limits, at this season extending to the Bonin Islands, are much less distinctly marked.

In the summer months, viz. from May to September inclusive, the mean temperature of the Kuro Siwo is 82°, or 7° higher than the mean temperature of the ocean, in the same latitude; it is during these months that the flow of tropical waters from the drift-currents of the Pacific, together with the monsoon drifts of the China Sea, unite to increase the velocity and raise the temperature of the Kuro Siwo.

In the months of April and October hot and cold belts are found alternating in the stream, the temperature of which belts differ from 7° to 10°; whilst during the winter months, viz. from November to March, the temperature of the stream, attaining in the latitude of Formosa a mean of 74° (which is rather higher than the temperature of the ocean in the same latitude), falls on reaching the shores of Japan to 63°, or below the temperature of the ocean at the same season: this may be accounted for by the fact that during these months the great body of water which lies to the westward of the Liu-Kiu Islands between the parallels of 26° N. and 28½° N., and which during the summer season flowed to the N.E. at the rate of from 20 to 30 miles a day, bringing warm water from the China Sea to join the Kuro Siwo, is now quiescent. Northward of this still water a cold current, forced down by the prevailing northerly winds in the Japan and Yellow seas and setting strong to the eastward between the parallels 29° N. and 31° N., flows through Van Diemen Strait and joins the Kuro Siwo, the temperature of which is thus considerably lowered; at the same time the stream is contracted to an

average width of 250 miles in the meridian of 142° E., and its velocity is diminished to a mean rate of two knots an hour, in consequence of the cessation of the supply of tropical waters.

The Kuro Siwo is, however, undoubtedly a warm current, its waters being generally of a higher temperature than that of the surrounding atmosphere. There is a floating seaweed found in the stream resembling the *Fucus natans* of the Gulf Stream.*

The Kamtchatka Current is a branch of the Kuro Siwo, from which it separates in the parallel of 40° N. on the meridian of 150° E., and flows to the north-eastward as far as 51° N., at an average rate of 18 miles a day, its breadth being about 200 miles: a branch then trends to the eastward towards the Aleutian Islands. Between the parallels of 51° N. and 60° N. there is a difficulty in tracing this current, but beyond 60° N. it is again found setting to the N.E.; passing W. of St. Matthew Island and E. of St. Lawrence Island, it flows along the American coast through Behring Strait into the Arctic Ocean; in this Strait the temperature of the sea on the American shore is 15° higher than that of the waters on the Asiatic shore. The channel between St. Lawrence Island and the coast of Asia is hampered with ice until July, while the coast of America is free from ice in the month of April.†

The Oya Siwo.—A counter current of cold water called the Oya Siwo sets to the southward, along the S.E. coast of Kamtchatka and the Kuril Islands, and, flowing along the E. coast of Yezo Island and N.E. coast of Nipon, is felt as far S. as Inaboye-saki. It varies in velocity and extent in the different seasons, being much stronger in the winter than in the summer. Except between the Kuril Islands, past Cape Noyshap, and through the Tsugar Strait, the force of the cold stream is about 18 miles a day; through these narrows, however, it sweeps occasionally with great speed, particularly during or after a strong north-easterly wind. Whirls, eddies, and tide rips take place off Cape Noyshap. This counter current is shown in Japanese itineraries, where the junk course is drawn well off shore, so as to avoid it by passing outside and getting into the Kamtchatka current.

During the spring (April), great quantities of floating ice are frequently brought down from the Kuril Islands and the northward, and are left grounded along the Yezo coast from Cape Yerimo eastward to Cape Noyshap.

* The remarks on the temperature of the Kuro Siwo are deduced from the observations taken by the United States expedition to Japan, 1854, the remark books of H.M.'s ships, documents in the Hydrographic Department of the Admiralty, and the observations of Captain J. O. Hopkins, H.M.S. *Liverpool*, 1870.

† Remarks of Dr. John Simpson, R.N., H.M.S. *Plover*, 1852.

The temperature of the Oya Siwo is from 10° to 15° lower than that of the Kuro Siwo, varying according to the season. The average temperature in May was 37° (10° below that of the surrounding atmosphere). It was 66° in July, between ten and thirty miles from the shore; when the temperature rose to 70°, or where it bordered on the Kamtchatka current flowing to the northward, this current was not perceptible. After passing westward round Inaboye-saki, the temperature of the sea water rose from 66° to 79° where the Kuro Siwo was setting N.E. by E. two knots an hour. The Oya Siwo is not felt close to the shore.

The drift of the N.E. Trade sets across the North Pacific Ocean, between the parallels of 9° and 22° N. A portion of this drift (to the northward of the Sandwich Islands) turns to the north-west, northward, and north-eastward, carrying a considerable body of warm water into the great bight between Vancouver Island and the peninsula of Alaska.

The Mexican Current is a continuation of the drift setting to the southward along the Californian coast; it runs along the Mexican coast as far as the Gulf of Fonseca, where it is met and recurved to the westward by the set northward and westward from the Pacific counter current.

The Pacific Counter Current.—A large portion of the Equatorial current (see p. 140) sets to the W.N.W. along the N. coast of New Guinea; on reaching the shores of the Malay Archipelago this current recurves, and flowing to the eastward right across the Pacific Ocean between the parallels of about 4° to 8° N., forms the Pacific counter current. On reaching the American coast it appears to divide, the main portion curving to the northward, meeting and turning the Mexican stream about the Gulf of Fonseca, from which point the streams appear to run together to the westward; the other part turns to the southward, meeting the Peruvian stream between the American coast and the Galapagos Islands.

The Peruvian Current.—Northward of Valdivia there is a steady set along the coast of South America towards Panama of from 12 to 18 miles a day, running with greater strength between Arica and Pisco. This current is about 150 miles broad, and is known as the Peruvian current. About Payta the stream divides, the main body setting off from the coast to the W.N.W., and running at times with a velocity of 50 miles in twenty-four hours. A small branch of this current, about 60 miles broad, sets steadily towards Panama, at the rate of 24 to 36 miles a day, running round the Bay of Panama, and setting to the southward on the west side towards Punta Mala, especially between November and March.

The meeting of such powerful streams as the Mexican, Pacific counter, and Peruvian currents in the great bight of Panama, probably accounts for the extraordinary variable weather, with the tropical squalls, and conflicting currents, experienced in that neighbourhood.

The Equatorial Current, which may be considered as a continuation of the Peruvian stream, sets fairly across the Pacific, between the parallels of 4° N. and 10° S. There is a general tendency of its waters near the southern edge to turn to the southward; about the meridian of 180° it appears to divide, one portion running to the N.W. along the coast of New Guinea, the other trending to the S.W. towards the Australian coast. The Equatorial current, in the western part of the Pacific, is much affected by the westerly monsoon that prevails between the months of November and March.

The Australian Current is a branch of the Equatorial, setting along the east coast of Australia as far as the parallel of Sydney, where the off-shore portion is met and curved back to the E. and N.E. by the cold Antarctic current setting to the northward from the Antarctic regions. The meeting of the warm current setting from the South Pacific Ocean, with the cold current from the Antarctic regions, is the main cause of the bad weather and confused sea, generally to be found between Australia and New Zealand.

The S.E. Trade drift of the Pacific sets across the ocean, turning to the southward about the meridian of Tahiti. To the southward of lat. 30° S., the general movement of the waters appear to be to the southward and eastward towards Cape Horn.

Dangerous Current.—On the coast of Chili, between the parallels of 50° S. and 37° S., an easterly current setting *directly on to* the coast of Chili is always experienced. In thick or unsettled weather this part of the coast should therefore be approached with great caution.

In the Pacific, as in the Indian and Atlantic Oceans, there is a steady set to the northward from the Antarctic regions, setting to the N.E. in the neighbourhood of New Zealand and Cape Horn.

ICE.

North Atlantic Ocean.—In the frequented parts of the North Atlantic, the limits of field-ice in March extend from Newfoundland to the southward as far as lat. 42° N., and to the eastward of the meridian of 44° W.

Between April and July the limits of the field-ice region are slightly contracted, but icebergs may be met with within an area reaching out to the point where the meridian of 40° W. crosses the parallel of 40° N., and even to the E. and S. of this. By August the field-ice has disappeared, but icebergs are still met with when westward of the meridian of 38° W. or northward of the parallel of 41° N. During the winter months the seas are comparatively clear.*

This region of *Field-ice* should as much as possible be avoided by vessels bound to or from the United States and Canada. By making the necessary detour, the length of the passage will be but little increased, and the risk to life and property will be considerably reduced. The Cunard Company's steamships cross the meridian of 50° W. in lat. 43° N. on their outward, and in lat. 42° N. on their homeward, voyage; this detour, which ensures comparative safety, only adds about 150 miles to the distance by the great-circle course.

Southern Hemisphere.—In the high southern routes, adopted of late years by navigators in the voyages to and from Australia and New Zealand, the greatest number of icebergs have been seen in the summer season, or in November, December, and January, and the smallest number in June and July. It has also been observed that more icebergs are seen in March. During February, the limit of the iceberg region in the South Atlantic extends as far N. as 39° S., while in August they are rarely found to the northward of the 45th parallel.

* See Pilot Charts for the Atlantic Ocean, published by the Hydrographic Office of the Admiralty.

This change in the limits of the iceberg region is specially noticeable in that portion of the Atlantic Ocean to the eastward of Cape Horn, a district that should be navigated with great caution with regard to ice.

Numerous icebergs have also been fallen in with southward of Cape Leeuwin during January and February, in about the parallel of 44° S. and between the meridians of 105° and 140° E.

In making passages between the Cape of Good Hope and Australia, the sailor is cautioned against adopting a high southern route. By crossing the Indian Ocean, between the parallels of 42° and 43° S., the danger of encountering icebergs will not only be avoided, but better weather will most probably be experienced. Similarly between Australia or New Zealand, and Cape Horn, navigators are recommended to cross the Pacific Ocean on or near the parallel of 52° S., until reaching the neighbourhood of Cape Horn.

The indications of the Thermometer should not be neglected in these seas, as there is generally a diminution of temperature of the air and sea on approaching ice; this, however, must not be assumed as an infallible guide. Icebergs should, if possible, be passed to windward, to avoid the loose ice floating to leeward.*

GREAT-CIRCLE SAILING.

On the Application of the Principles of Great-Circle Sailing, to making Ocean Passages.

Before the shelter of the port is quitted, whether able to choose the time for sailing, or obliged to start at a predetermined hour, due regard should be paid to the wind and weather, tide and current, that may be experienced on leaving the harbour.

When clear of land, and having a sufficient offing, the course to be shaped is again subject to the various considerations of wind and weather, together with those of the shortest distance, the safest track, and the greatest speed.

* For more detailed information on this important subject, sailors are referred to the Ice Chart of the Antarctic regions, No. 1241, published by the Hydrographic Office of the *Admiralty*.

In a long voyage the arc of a great circle should be *traced on the chart* as a guide, to be *closely* followed only if wind or other circumstances are favourable to such a course. For this purpose a piece of string stretched from port to port upon a small terrestrial globe, will show at a glance the course of the arc of a great circle between those places.

When driven, or otherwise separated a considerable distance from an intended track, on the chart, a new course, or arc, should be traced, or reference made *by eye* to the first one—which should *not* be purposely regained.

In high latitudes such a consideration should always be kept in view while deciding on which tack to lay the ship.

Great-circle sailing being now much used by steamers and sailing vessels frequenting high latitudes, a ready way of finding the great circle course and distance in an easy and quick manner—accurate within sufficient limits—will be found useful to navigators, when elaborate rules are not immediately available.

It should be borne in mind that land, ice, weather, current, or other causes, considerably limit the adoption of great circle sailing; and that along or near a meridian, as well as within a few degrees of the Equator, all straight lines on Mercator's chart nearly represent arcs of great circles. Mixed or composite courses may generally be drawn by eye after tracing a great-circle arc.

The following is Professor Airy's method for sweeping an arc of a circle on one side of the Equator (on Mercator's chart), which approaches nearest to the correct projection of a great circle.

RULE.

1.—Join the two points, between which it is required to project the great circle, by a straight line. Bisect this line, and from the point of section erect a perpendicular to the line on the side next the Equator, continuing it if necessary beyond the Equator.

2.—With the middle latitude (between the two places) enter the following table, and take out the "corresponding parallel."

3.—The centre of the arc of the great circle, required to be drawn, will be the intersection of this parallel with the perpendicular.

Professor Airy's Table for drawing Arcs of Great Circles on a Mercator's Chart.

Middle Latitude.		Corresponding Parallel.
20°	Opposite name to lat. of points.	81° 13′
22		78 16
24		74 59
26		71 26
28		67 38
30		63 37
32		59 25
34		55 5
36		50 36
38		46 0
40		41 18
42		36 31
44		31 38
46		26 42
48		21 42
50		16 39
52		11 33
54		6 24
56		1 13
58	Same name as lat. of points.	4 0
60		9 15
62		14 32
64		19 50
66		25 9
68		30 30
70		35 52
72		41 14
74		46 37
76		52 1
78		57 25
80		62 51

Navigators owe the late Astronomer Royal much gratitude for his rule, which is the best that has yet been devised for the purpose, being easy of application and accurate in principle.

REMARKS UPON A CHART AND DIAGRAM FOR FACILITATING GREAT-CIRCLE SAILING, BY HUGH GODFRAY.

Godfray's Great-Circle Chart and Course and Distance Diagram answer all the conditions of great-circle sailing as completely and as simply as Mercator's chart does for sailing on a Rhumb. The track is a straight line which may be drawn and examined; then the various courses and the distances to be run upon each course are obtained, as also the distance from the ship to her destination, by a mere inspection of the diagram.*

Construction of the Great-Circle Chart.

Draw a tangent plane at any selected point of a terrestrial globe; then supposing the eye at the centre of the globe, project the coast line of the various continents and islands upon the tangent plane. The result will be a chart on the central projection. Every great circle of the globe will be projected into a straight line, and the shortest route from point to point will, on the chart, be represented by the straight line which joins them.

In the chart engraved by the Hydrographic Office (1858) the South Pole is made the centre of projection, and a series of concentric circles represent the parallels of latitude, the radius of any parallel being r and $\cot$ (lat.), where r is the radius of the parallel of 45°. The meridians are straight lines drawn from the centre, dividing each circumference into 360 equal parts. One of these being selected for the meridian of Greenwich, the coast lines of the different countries are traced in the usual manner by means of the latitude and longitude of the different points.

The magnitude of the circles increases so rapidly in low latitudes—becoming infinite at the Equator—that it is impossible to bring in the equatorial regions when the Pole is made the centre of the chart, and even the 10th parallel of latitude cannot be introduced into any moderate-sized sheet without making the higher latitudes indistinct from their reduced dimensions. The chart extends to 20° latitude.

The difference between the track by great circle and by Mercator is so small, both as to length and as to position when a ship has to cross or to approach the Equator, that the one sailing has no practical advantage over the other.

* See Chart to facilitate the practice of Great Circle Sailing, with accompanying Diagram for the determination of Courses and Distances: by Hugh Godfray, Esq., M.A. Sold by J. D. Potter, 31, Poultry, London, E.C.

Description of the Course and Distance Diagram.

The object of this diagram is, as its name implies, to determine the course or rather the succession of courses which the ship must follow to keep on the great-circle track, and the distance from any one point on the chart to any other.

The course on a great circle changes continually from point to point. It would be impossible for a ship, with the compass for its guide, to be put on this ever-varying course; the helmsman must be told what course to steer, and may be instructed to alter it after running a certain number of miles or a certain time; but to alter it every instant according to a definite law would be altogether impossible. The nearest quarter point is the greatest amount of nicety ever aimed at, and he is a good helmsman who can secure that under the most favourable circumstances.

The diagram is constructed so as to give the quarter point nearest to the true course, and also the distance to be run on that quarter point before the next one is substituted for it. The course can therefore never be more than one-eighth of a point in error, and while running one of these distances the error will be one way during the first half and the other way in the second, vanishing altogether about the middle, so that the compensation will be nearly perfect, and the route thus marked out will not perceptibly differ in position from the real great-circle track.

The diagram consists of a series of concentric curves corresponding to the parallels of latitude, bounded by a horizontal and a vertical line; the degrees of latitude are marked on the latter, and the distances from the highest latitude on the former at intervals of one hundred nautical miles, and through the various points of division are drawn horizontal and vertical straight lines over the whole figure. All these are again intersected by thirty-two curve lines, the spaces between which are alternately light and shaded, marked in points and quarter points for the determination of the courses.

Use of the Chart and Diagram.

Given the latitudes and longitudes of the ship and of her destination, to find the courses and distances to be run in order to follow the great circle—

Find the ship's place on the chart and join it by a straight line with the port or place bound to. This will be the great-circle track. Note the direction of the track near the ship's place, *i.e.* whether from N. or S.

towards E. or W. Note also the highest latitude of the track, *i.e.* the latitude of the place where (produced if necessary) it approaches nearest to the pole. (This will always be found with sufficient accuracy by a mere inspection of the chart; but the exact point may be obtained by letting fall a perpendicular from the Pole on the track.)

Now refer to the diagram, and along the horizontal line corresponding to the highest latitude, find the point where it intersects the curve corresponding to the latitude of the ship. This point, which may be called the *ship's place on the diagram*, will fall in one of the light or shaded spaces, and will indicate the course to be steered in points and quarter points, from N. or S. towards E. or W., as previously found; and at the same time its position relatively to the vertical lines will give the distance from the highest latitude in miles.

We must, in the next place, determine how far the ship must run upon the course so found; and this will be done by proceeding along the horizontal line which represents the ship's course on the diagram (going towards the increasing or decreasing latitudes as the track on the chart will indicate) until we reach the light or shaded space corresponding to the next quarter point. The difference between the two corresponding numbers at the top of the diagram will be the distance to run on that first course, but it will be found easier to measure the distance with a pair of compasses and apply it to the small scale of Nautical Miles at the bottom of the diagram; and in the same manner may the distances to be run on the successive courses be known.

Construction of the Course and Latitude Curves.

At the highest latitude of a great-circle track, the course is evidently due E. or W., and as we move along the track away from the highest latitude, we shall find the course altering continuously as the distance alters, the connection between the course and the distance being determined by the solution of a right-angled triangle.

If l be the highest latitude, d the distance in nautical miles from the highest latitude, A the course or angle made by the track at that distance with the meridian, we have

$$\sin \frac{d}{60} = \cot A - \cot l \quad . \quad . \quad . \quad . \quad (1)$$

which determines the distance of the point where the course is A; and the curve for the course A in the diagram must pass through that point where

the horizontal line corresponding to the *highest latitude* l is met by the vertical line at distance d. If we thus determine the distance d for different values of l, we shall have a series of points through which the curve of the course A may be drawn.

The latitude quadrants are traced in a similar manner. If l be the highest latitude of a great-circle track, l' be any other lower latitude on this track, u be the number of nautical miles between them, we find

$$\sin l' = \sin l \cdot \cos \frac{u}{60}$$

Therefore

$$\cos \frac{u}{60} = \sin l' \cdot \sin l \quad . \quad . \quad . \quad . \quad (2)$$

which determines u, the distance at which the latitude curve l' crosses the horizontal line l.

Composite Sailing.

A modification of great-circle sailing has received the name of Composite Sailing. It presents itself whenever the great-circle track by passing too close to the Pole becomes dangerous or impracticable on account of the ice which pervades those high latitudes. When this occurs, some one parallel of latitude is fixed upon for the maximum, then the shortest route, under these circumstances, will consist of a portion of that parallel and of parts of the two great circles which touch it and which pass—one through the ship and the other through the destination. On the great-circle chart the track will be shown by the two straight lines drawn from the two places so as to touch the circle of highest latitude, and the part of this circle between the points of contact. This combination of great-circle sailing and parallel sailing offers therefore no difficulty.

Example :—A ship in lat. 30° S., long. 18° W., is bound to Melbourne.

Mark the ship's place on the chart, and draw the great-circle track. It will be found to reach 77½° S., and is consequently impracticable. Suppose 55° to be the highest latitude decided on.

From the ship's place on the chart draw a straight line to touch the parallel of latitude 55°. From Melbourne draw a straight line to touch the same parallel. These two straight lines and the part of the intercepted parallel constitute the track, the portion on the parallel being due E.

The lengths of the two parts from the ship to the parallel of 55°, and from 55° to Melbourne, are respectively 3146 and 2527 miles. The portion of the parallel being 1330 miles. The total distance is 7003 miles, being 400 miles longer than the direct great-circle track, and 1130 miles shorter than the rhumb track.

It is not to be expected, nor indeed to be desired, that great-circle sailing should supersede the methods now in use, but it is very desirable that it should form a part of the sailor's nautical knowledge, not necessarily for him to adopt in all cases, but that he may know which is the shortest route, that he may see it on his chart, and that he may be able to follow it if his judgment tells him it is both practicable and preferable.

Use of the Terrestrial Globe in Great-Circle Sailing.

As has been before remarked, all questions of great-circle sailing can easily be solved by the aid of a small terrestrial globe. A piece of fine silk thread tightly stretched across the globe from port to port will show the track of the great circle between those ports. Mark the points upon the several meridians where the silk thread passes over them, and note the latitudes and longitudes of these intersections. Mark the positions thus obtained upon the Mercator's chart in use: then the track drawn from port to port *through these positions* will show the required great-circle track.

In Composite sailing, the point of the maximum latitude having been decided upon, the operation of finding the great-circle tracks between that point and the respective ports, by first drawing the great circles upon the globe, and then transferring them to the Mercator's chart, can easily be performed as above described.

PASSAGE TABLES.*

THE average rate of a *Sailing* Vessel in making general ocean passages may be taken as 120 nautical miles a day, and of a *Steam* Vessel as 200 nautical miles a day.

4	miles an hour =	96	miles a day, or	672	miles a week.
5	„ =	120	„	840	„
6	„ =	144	„	1008	„
7	„ =	168	„	1176	„
8	„ =	192	„	1344	„
9	„ =	216	„	1512	„
10	„ =	240	„	1680	„
11	„ =	264	„	1848	„
12	„ =	288	„	2016	„
13	„ =	312	„	2184	„
14	„ =	336	„	2352	„
15	„ =	360	„	2520	„

In the following tables the miles noted under the head of "Steam," show the distance to be traversed by a ship making a direct course, on the most favourable track for steam vessels, between port and port.

Passages noted under the head of "Sail," show the distances that will probably have to be run by sailing vessels; the prevailing winds and currents being taken into consideration.

* For a complete set of Passage Tables of the navigable mercatorial distances between most of the known ports of the globe, calculated by Commander Thomas A. Hull, R.N., *see The Sailor's Handbook*, published by Messrs. Griffin and Co., The Hard, Portsea.

Navigable Distances in Nautical Miles between some of the principal Ports of the Globe.

ENGLAND TO PORTS IN INDIA, CHINA, AND AUSTRALIA.

PORTS.	By Cape of Good Hope.			By Suez Canal.
	Steam.	Sail.	Sail. N.E. Monsoon.	
	Miles.	Miles.	Miles.	Miles.
Plymouth to Bombay	10,424	11,727	13,290	6,002
,, Galle	10,181	11,470	12,200	6,499
,, Madras	10,683	11,990	14,200	7,014
,, Calcutta	11,311	12,610	14,200	7,679
,, Singapore	11,546	13,160	—	7,996
,, Hong Kong ..	12,844	14,600	15,140	9,435
,, Shanghai	13,510	15,400	16,140	10,171
,, Yokohama ..	14,202	16,160	—	10,898
,, Melbourne	11,882	13,200	—	10,805
,, Sydney	12,343	13,750	—	11,269
,, Wellington	13,237	14,670	—	12,160

ENGLAND TO PORTS IN THE PACIFIC AND BACK.

PORTS.	By Cape Horn.	
	Steam, *vid* Magellan.	Sail, by Cape Horn and Valparaiso.
	Miles.	Miles.
Plymouth to Valparaiso	8,531	9,120
,, San Francisco	13,295	15,360
,, Vancouver	14,035	16,110
,, Honolulu	13,555	15,180
Valparaiso to Plymouth	—	9,800
San Francisco ,, } By sail direct	14,750	16,430
Vancouver ,, } By sail direct	15,450	17,170
Honolulu ,, } By sail direct	15,100	17,280

AUSTRALIA TO ENGLAND BY CAPE HORN.

PORTS.	Steam.	Sail.
	Miles.	Miles.
Melbourne to Plymouth	13060	13940
Sydney to Plymouth	12870	13750
Wellington to Plymouth	11670	12550

British Islands, North Sea, etc.

PORTS.	DISTANCE.
	Nautical Miles.
Liverpool to Stornoway	345
„ Oban	225
„ Glasgow	210
„ Dublin	118
„ Belfast	137
„ Plymouth	330
„ Portsmouth	457
„ London	647
„ Queenstown	235
„ Gibraltar	1267
Dublin to Holyhead	58
„ Glasgow	194
„ Queenstown	160
Queenstown to Glasgow	335
„ Bristol	225
„ Cape Clear	57
„ Plymouth	212
„ Portsmouth	330
„ London	552
„ Lisbon	785
„ Gibraltar	1009
Plymouth to Dartmouth	31
„ Portland	78
„ Portsmouth	127
„ London	317
„ Pembroke	190
„ Ushant	120
„ Brest	150
„ Glasgow	460
Portsmouth to Cherbourg	77
„ Ushant	210
„ Havre	91
„ Boulogne	105
„ Dover	102
„ Sheerness	150
„ London	192
„ Leith	484
„ Glasgow	574
„ Antwerp	236
„ Wilhelmshaven	450
„ Hamburg	500
„ Copenhagen	780
„ Cape Farewell, Greenland	1610

British Islands, North Sea, etc. (*continued*).

PORTS.	DISTANCE.
	Nautical Miles.
Portsmouth to Lively, Disko Island, Greenland	2330
" Smith's Sound	2990
" Lisbon	855
Sheerness to Harwich	44
" Aberdeen	400
" Amsterdam	234
" Skaw	535
" Hammerfest	1384
Dover to Leith	384
" Hull	202
" London	90
" Boulogne	26
" Calais	22
" Ostend	62
" Flushing	87
" Antwerp	135
London to Copenhagen	700
" Christiania	656
" Trondheim	911
" Hamburg	423
" Amsterdam	225
" Antwerp	177
Hull to Copenhagen	600
" Christiania	540
" Trondheim	750
" Hamburg	380
" Hammerfest	1250
" London	228
" Antwerp	240
" Amsterdam	206
Aberdeen to Trondheim	550
" Kirkwall	130
" Reikiavik (Iceland)	830
" South Cape, Spitzbergen	1230
Reikiavik to Cape Farewell, Greenland	685
Copenhagen to Kiel	195
" Christiania	260
" Stockholm	370
" Danzig	260
" Memel	330
" Riga	480
" Kronstadt	670
Hammerfest to Archangel	650

Atlantic.

PORTS.	STEAM.	SAIL.
	Naut. Miles.	Naut. Miles.
Plymouth to Quebec	2691	—
„ St. John's, Newfoundland	1905	—
„ Halifax	2434	—
„ „ Northern Passage	—	2400
„ „ Southern Passage	—	4200
„ New York	3040	—
„ Bermuda	2920	3780
„ Jamaica	4029	—
„ St. Thomas	3505	3700
„ Colon	4526	4740
„ Barbadoes	3538	—
„ Demerara	3779	4080
„ Maranham	3880	3980
„ Lisbon	765	—
„ Madeira	1210	1210
„ Gibraltar	1050	1050
„ Fayal	1261	1261
„ Teneriffe	1420	1420
„ St. Vincent	2257	2257
„ Sierra Leone	2740	2740
„ Ascension	3620	4200
„ Cape of Good Hope	5882	7200
„ Rio de Janeiro	4939	4939
„ Monte Video	5926	5926
„ Cape Horn	7155	7155
Gibraltar to Madeira	603	603
„ Bermuda	2880	3240
„ Halifax	2670	3840
„ St. Vincent	1565	1565
Halifax to Plymouth	2434	2434
„ St. John's, Newfoundland	508	—
„ New York	580	580
„ Gibraltar	2670	2670
„ Bermuda	750	750
„ Quebec by Gut of Canso	748	—
Bermuda to Plymouth	2920	2920
„ Jamaica	1108	—
„ St. Thomas	838	838
„ Demerara	1570	1570
„ Havana	1140	1140
„ Cape of Good Hope	6127	—
„ New York	690	690
„ Gibraltar	2880	2880
New York to Havana	1187	1187
Havana to New Orleans	580	580
„ Vera Cruz	807	807
Jamaica to Colon	547	547

Atlantic—(*continued*).

PORTS.	STEAM.	SAIL.
	Naut. Miles.	Naut. Miles.
Jamaica to Havana	702	—
" Barbados	1041	—
" Sierra Leone	3781	—
St. Thomas to Colon	1020	—
" Santa Marta	690	—
" Cartagena	785	—
Sierra Leone to Cape Coast Castle	865	865
" Plymouth	2740	4290
" Ascension	1000	1500
" Rio de Janeiro	2599	—
Cape Coast Castle to Fernando Po	613	613
" Plymouth	3561	5700
Fernando Po to Sierra Leone	1465	1800
" St. Helena	1460	1980
Ascension to Plymouth	3620	4760
" Sierra Leone	1000	1000
" Rio de Janeiro	1890	1890
" St. Helena	697	2460
" Cape of Good Hope	2416	3420
St. Helena to Cape of Good Hope	1720	2700
" Plymouth	4225	5440
" Rio de Janeiro	2140	2140
Rio de Janeiro to Plymouth	4939	5600
" " (Nov. to Feb.)	—	6300
" Ascension	1890	2760
" St. Helena	2140	2760
" Bahia	737	—
" Pernambuco	1073	—
" Monte Video	1020	—
" Falkland Islands	1872	—
" Cape Horn	2261	—
" Valparaiso (*viâ* Magellan Straits)	3631	4180
" Cape of Good Hope	3270	3270
Monte Video to Plymouth	5926	6620
" " (Oct. to April)	—	7020
" Cape of Good Hope	3600	3600
" Falkland Islands	1002	—
Cape of Good Hope to Plymouth	5882	7140
" New York	6817	6817
" Rio de Janeiro	3600	3600
" Algoa Bay	367	—
" Natal	746	—
Cape Horn to Plymouth	7155	8000
" St. Helena	3720	3720
Cape Virgins to Cape Pilar	304	—

Mediterranean.

Ports.		Distances. Naut. Miles.
London to	Gibraltar	1323
Liverpool	„	1267
Plymouth	„	1050
Halifax	„	2710
New York	„	3256
Bermuda	„	2968
Jamaica	„	3963
Barbados	„	3397
Rio de Janeiro	„	4210
Sierra Leone	„	1977
Gibraltar to	Cartagena	236
„	Port Mahon	524
„	Marseilles	687
„	Toulon	697
„	Spezzia	867
„	Naples	975
„	Messina	1025
„	Palermo	913
„	Malta	980
„	Brindisi	1283
„	Corfu	1298
„	Patras	1302
„	Piræus	1490
„	Salonika	1694
„	Gallipoli	1680
„	Constantinople	1800
„	Smyrna	1650
„	Famagousta	1955
„	Beirut	2009

Ports.		Distances. Naut. Miles.
Gibraltar to	Port Said	1915
„	Alexandria	1794
„	Tripoli	1072
„	Sphax	1009
„	Cape Bon	800
„	Cagliari	726
„	Bonifacio	750
„	Algiers	408
Marseilles to	Spezzia	223
„	Naples	449
„	Messina	580
„	Palermo	495
„	Malta	634
„	Cape Bon	468
„	Bona	400
„	Algiers	480
Algiers to	Naples	557
„	Palermo	504
„	Cape Bon	389
„	Tripoli	661
Malta to	Cartagena	768
„	Toulon	602
„	Spezzia	551
„	Naples	327
„	Palermo	223
„	Brindisi	360
„	Corfu	365
„	Patras	374
„	Piræus	512

Mediterranean—(*continued*).

PORTS.	DISTANCES. Naut. Miles.
Malta to Salonika	724
„ Gallipoli	710
„ Constantinople	825
„ Smyrna	674
„ Famagousta	984
„ Beirut	1038
„ Port Said	935
„ Alexandria	820
„ Tripoli	198
„ Sphax	223
„ Cape Bon	184
„ Algiers	573
„ Cagliari	326
„ Port Mahon	541
Tripoli to Alexandria	854
Messina to Brindisi	258
„ Corfu	273
„ Patras	307
„ Piræus	494
„ Constantinople	805
„ Smyrna	654
„ Famagousta	961
„ Beirut	1015
„ Port Said	930
„ Alexandria	818
„ Palermo	118
„ Malta	152
Brindisi to Smyrna	638
„ Venice	380
„ Corfu	116
Brindisi to Piræus	481
„ Constantinople	788
„ Famagousta	952
„ Beirut	1008
„ Port Said	930
„ Alexandria	830
Constantinople to Odessa	337
„ Sebastopol	290
„ Piræus	358
„ Smyrna	283
„ Famagousta	781
„ Beirut	834
„ Port Said	795
„ Alexandria	735
Smyrna to Famagousta	579
„ Beirut	670
„ Port Said	628
„ Alexandria	540
Famagousta to Beirut	105
„ Port Said	250
„ Alexandria	328
Beirut to Port Said	227
„ Alexandria	333
Port Said to Bombay	3032
„ Calcutta	4709
„ Singapore	5026
„ Melbourne	7835
„ Batavia	5287
„ Mauritius	3730
„ Zanzibar	3108

Indian Ocean.

PORTS.	STEAM.	SAIL.
	Naut. Miles.	Naut. Miles.
Port Said to Suez	87	—
Suez to Aden	1308	—
„ Jiddah	630	—
Aden to Bombay	1637	1637*
„ Karachi	1437	—
„ Basrah	2490	—
Bombay to Aden	2180*	3975*
„ Karachi	483	—
Aden to Point de Galle	2134	2134*
Point de Galle to Aden	2480*	3255*
Bombay to Point de Galle	906	—
Calcutta to Aden	3314*	4395*
„ Bombay	2086*	5000*
Aden to Seychelles	1398	3130*
„ Diego Garcia	2085	—
„ Zanzibar	1713	1713†
„ Mauritius	2830*	3610*
„ Batavia	3960*	—
„ „	4090†	—
„ Cape Leeuwin	4958	—
„ Adelaide	6135	—
„ Melbourne	6440	—
„ Sydney	6904	—
„ Hobarton	6591	—
„ Wellington	7795	—
Batavia to Aden	4090*	—
„ „	3960†	—
Seychelles to Zanzibar	1017	1017
„ Mauritius	934	—
„ Bombay	1740	1740*
Zanzibar to Cape of Good Hope	2339	—
„ Bombay	2498	2498*
Bombay to Cape of Good Hope	4542	4542†
„ „	—	5820*
„ Diego Garcia	1569	—
„ Basrah	1577	—
Mauritius to Point de Galle	2063	2063*
„ Diego Garcia	1167	—
„ Cape of Good Hope	2251	2251
„ Cape Leeuwin	3173	—
Natal to Mauritius	1549	2400
„ Cape of Good Hope	746	—
„ Algoa Bay	367	—
Point de Galle to Maulmein	1192	—
„ Batavia	1783	—
„ Zanzibar	2580	—
„ Seychelles	1620	—

* In S.W. Monsoon. † In N.E. Monsoon.

Indian Ocean, China Sea, Australia.

PORTS.	STEAM.	SAIL.
	Naut. Miles.	Naut. Miles.
Point de Galle to Trincomalee	250	—
" Madras	525	—
" Calcutta	1180	1180*
" Singapore	1497	3065
" Diego Garcia	935	—
" Perth, W. Australia	3059	—
" Cape Leeuwin	3130	—
" Melbourne	4612	—
" Cape of Good Hope	4299	4299†
" "	—	4860*
Cape of Good Hope to Bombay	4542	6090†
" Calcutta	5429	7000†
" Madras	4801	7000†
" Diego Garcia	3416	—
" Straits of Sunda	5141	5460
" Singapore	5664	5960
" Perth, W. Australia	4900	4900
" Melbourne	6000	6000
" Mauritius	2340	3120
Calcutta to Cape of Good Hope	—	5580†
" "	—	6600*
" Singapore	1630	1630
Madras to Cape of Good Hope	4801	4960†
" "	—	5520*
" Bombay	1431	4320*
" Singapore	1607	—
Singapore to Melbourne, by Strait of Sunda	3806	5100
" " by Baly Strait	4676	4800
" Sydney (N. W. Monsoon)	4380	4380
" Batavia	509	—
" Cape York	2460	2460
Batavia to Cape York	2149	—
Hong Kong to Sydney (N.W. Monsoon), Torres Strait	4620	4620
" " " N. of New Guinea	5040	5040
Singapore to Hong Kong	1440	1980†
Hong Kong to Shanghai	824	1000†
" Singapore	1440	1980*
" Yokohama	1575	—
" River Amur	2415	—
River Amur to Petropaulski	836	—
King George's Sound to Adelaide	1019	—
Adelaide to Melbourne	498	—
Melbourne to Sydney	576	—
" Cape of Good Hope	6800	6800
Sydney to Brisbane	473	—
Brisbane to Townsville	688	—
Townsville to Cape York	604	—

* In S.W. Monsoon. † In N.E. Monsoon.

Pacific.

Ports.	Steam.	Sail.
	Naut. Miles.	Naut. Miles.
Rio de Janeiro to Valparaiso	3631*	4180
Cape Horn to Valparaiso	1578	—
,, San Francisco	6342	7700
Valparaiso to Panama	2622	2622
,, Acapulco	3381	—
,, San Francisco	5114	6240
,, Vancouver's Island	5911	6990
,, Yokohama	9326	—
,, Hong Kong	10,521	—
,, Honolulu	5942	5942
,, Tahiti	4308	4308
,, Levuka	5982	—
,, Callao	1295	1295
,, Sydney	7950	7950
Callao to Valparaiso	1295	2400
,, Payta	490	—
,, Guayaquil	708	—
,, Tahiti	4196	—
,, Levuka	6098	—
Guayaquil to Panama	821	—
Panama to Callao	1330	4620
,, Valparaiso	2822	4320
,, Realejo	663	—
,, Acapulco	1411	—
,, Mazatlan	1983	—
,, San Francisco	3243	5200
,, Vancouver's Island	3968	5940
,, Yokohama	8019	—
,, Hong Kong	9726	—
,, Honolulu	5200	5200
,, Tahiti	4475	4475
,, Levuka	6278	—
,, Sydney	7954	7954
,, Wellington	6790	6874
Acapulco to Mazatlan	572	—
,, San Francisco	1832	—
San Francisco to Mazatlan	1341	—
,, Honolulu	2086	2086
,, Yokohama	4500	—
,, Hong Kong	6940	5680
,, Vancouver's Island	740	740
,, Sydney	6463	6463
,, Wellington	5820	5820
,, Levuka	4703	4703
,, Cape Horn	6342	6500

* By Magellan.

Pacific (*continued*).

PORTS.	STEAM.	SAIL.
	Miles.	Miles.
Vancouver's Island to Valparaiso	5911	6820
" Hong Kong	6093	—
" Levuka	5063	—
" Sydney	6764	—
" Auckland	6121	—
Petropaulski to Vancouver's Island	2920	2920
" Honolulu	2820	2820
Honolulu to Petropaulski	—	3450
" Behring Straits	—	2820
" Vancouver's Island	2343	2580
" Panama	5280	5280
" San Francisco	2086	2280
" Yokohama	3393	3600
" Hong Kong	4860	4860
" Sydney	4410	4410
" Tahiti	2445	—
" Valparaiso	5942	7300
" Levuka	2715	2715
" Cape Horn	6598	7100
Yokohama to Vancouver's Island	4300	4300
" San Francisco	4500	4500
" Shanghai	1068	—
Nagasaki to Shanghai	470	—
Shanghai to Tientsin	711	—
Yokohama to Hong Kong	1575	—
Hong Kong to Manila	650	—
Tahiti to Wellington	2400	2400
" Cape Horn	4434	4655
" Sydney	3480	3480
" Levuka	1902	1902
Sydney to Wellington	1200	1200
" Auckland	1260	1260
" Panama	—	8100
" Valparaiso	—	6240
" Cape Horn	—	5750
" Hong Kong	4456	5820
" Shanghai	4675	5700
" Yokohama	4504	5280
" Levuka	1786	—
Melbourne to Wellington	1470	1470
" Cape Horn	5940	5940
" Levuka	2289	—
Auckland to Levuka	1162	—
" to Wellington	528	—
Wellington to Lyttleton	171	—
Lyttleton to Otago	181	—

Table showing whether a Vessel gains or loses by keeping away a given number of Points from the True Course, thereby enabling her to economize Fuel.

The upper line shows the rate in knots per hour steaming head to wind. The other lines show the rate in knots a ship must go, if she keeps away, to be in as good a position as she would have been had she held on her course.

Points from the wind.	RATE IN KNOTS PER HOUR.								
0	1	2	3	4	5	6	7	8	9
1	1·02	2·04	3·06	4·08	5·1	6·12	7·14	8·16	9·17
2	1·08	2·16	3·25	4·33	5·41	6·49	7·58	8·66	9·74
3	1·2	2·4	3·61	4·81	6·0	7·21	8·42	9·6	10·89
4	1·4	2·83	4·24	5·65	7·07	8·48	9·9	11·3	12·73
5	1·8	3·6	5·4	7·2	9·0	10·8	12·6	14·4	16·2
6	2·6	5·2	7·84	10·45	13·06	15·68	18·3	20·9	23·52

Example.—A ship is able to steam 4 knots an hour head to wind; by keeping away 4 points, and setting fore-and-aft sails, she makes 6 knots an hour. The table shows that if she made 5·65 knots, she would be in as good a position as if she had remained steering head to wind; therefore, if she can steam 6 knots, she gains nearly half a knot an hour; but if she can only steam and sail at the rate of 5 knots, she is losing.

If the vessel keeps away 5 points she must steam or sail at the rate of 7·2 knots to be in an equally good position.

SECTION V.

LIGHTS — BUOYS — HYDROGRAPHICAL ABBREVIATIONS — SOUNDING—DETERMINING POSITIONS—MEASURING DISTANCES AND HEIGHTS.

LIGHTS.

The lights shown in lighthouses are divided into two principal classes—Fixed and Variable. The fixed light maintains the same appearance; the variable lights change—some alternating by slow degrees between bright and dim; some flashing more or less suddenly; and others intermitting altogether. Colour is also employed as a means of distinction. Variable lights are distinguished from each other also by the different intervals of time in which the changes succeed each other, the effect of such changes being generally produced by a revolving motion.

It is to be borne in mind that every light which varies its lustre is liable, when seen from a distance, to become invisible during the period of lesser brilliancy; that is, a revolving light may seem to intermit. Also, elevated lights are often obscured by clouds.

As objects painted white are frequently lost sight of in a fog, while objects of a red colour remain visible, buildings serving as marks for sailors are generally painted with red and white stripes or bands. Light*houses*, therefore, being useful as guides by day, are often so painted in order to answer this second purpose. Light vessels are coloured red.

The Charts and Sailing Directions should therefore be carefully studied by the sailor, so that he may be well acquainted with the nature of the lights and lighthouses of the coast he has to navigate. As changes in the character of lights and lighthouses are constantly occurring, one of the sailor's most important duties is to take care that his charts, at the time of sailing, are corrected up to date. *See* note on p. 90.

Lists of all the known lights in the world, arranged in geographical order, wherein a full description is given of each light, are published every year by the Hydrographic Office of the Admiralty.*

Systems.—Two systems of lighting are in general use—(1) the catoptric, or reflecting system, and (2) the dioptric, or refracting one. The catoptric is usually produced by Argand burners, shown in the focus of paraboloidal silvered metal reflectors, any number of which may be placed on the same plane as the power and range may require.

In the dioptric system, the light is produced from one central lamp placed in the focus of a glass instrument, by which all the rays emanating from the sections of the flame best suited for the purpose, are bent, so as to be sent nearly horizontally, and only to the surface of the sea.

* See Admiralty Lists of Lights, published by J. D. Potter, Poultry, E.C.

The Catadioptric system is a combination of the two preceding systems. Both of these systems admit of lights being shown as fixed, revolving or flashing, and of various orders, determined in the catoptric by the number of lamps and reflectors, and in the dioptric by the size of the instrument, with a corresponding central flame.

The illuminant common to both in England is oil (either colza or paraffin) or gas; but abroad, olive, cocoa-nut, or lard oil can be used when more convenient.

In addition to these two well-known systems is that of the magneto-electro light; it belongs to the dioptric class, the light being shown from an apparatus of that character.

Each of these systems presents some conditions which give it a superiority over the other, and these conditions may be briefly enumerated as follows:—

A Catoptric revolving light may, according to the number of burners and metallic reflectors used, be deemed equal to a dioptric light. Seven reflectors on a face revolving are generally used, and are worked at about the same cost as a first order dioptric light. Where, however, there are ten reflectors on a face, as at Beachy Head, Scilly, etc., the great volume of light, with a slow revolution, shows a superiority over the intensified flame of the lens, and coming to the eye with a great body of light, it illumes to a greater extent the atmosphere, and thus has an advantage, especially where there is a haze.

The catoptric system has the further advantage over the dioptric of facility in erection, at a distance from where skilled mechanics are obtainable, requiring less delicacy in putting up and focussing the light, and being less liable to be put out of adjustment by volcanic or other disturbances. It has also the advantage that its first cost is not more than half that of a dioptric light, and, with care in the use and cleaning of the reflectors, its consumption of oil and stores, except in the case of ten reflectors on a face, is not more than that of the lenticular light.

The power of a reflector is much increased by what is termed the holophotal arrangement, where an annular lens is placed in front of the frame, while all the back rays of light, which are otherwise lost, are thrown back into the flame by a hemispherical mirror. Three reflectors of this kind to a face make an excellent revolving light.

For a *fixed* light, however, the catoptric is far inferior to the dioptric *system*, and is now only used for lights of that character in positions where

want of importance does not warrant the use of a lens; but it possesses one advantage, that it is not in the same degree subject to be deteriorated for want of care and skill on the part of the attendants.

In a Catoptric Fixed Light—the reflectors (with an Argand lamp in the focus of each) are arranged round a circular frame, and if intended to illuminate the whole horizon, there are generally thirteen in each tier; those in the second tier being placed over the interstices of the other, so as to produce as nearly as possible an equal distribution of light.

The reflectors generally used are twenty-one inches in diameter at the lips, and the Argand burner seven-eighths of an inch.

In a Catoptric Revolving Light—the reflectors are grouped together with their axes parallel to each other on three or more faces, so as to throw their combined light in one direction.

The number of faces depend upon the rapidity of revolution, and shortness of flash intended to be given; but where the interval between the appearance of each face amounts to half a minute or more, there are usually only three faces; which may contain one or more reflectors each.

Dioptric Lights, whether fixed, revolving, or flashing, vary in the size of the lamp and apparatus according to the order required, and are numbered from 1 to 6. The 1st, 2nd, and 3rd orders are all used for coast illumination; the 4th, 5th, and 6th order lights are generally employed at the entrance of harbours, or as lower leading lights. The 1st order is that chiefly in use at the English lighthouses. As a fixed light the dioptric possesses great advantages over the catoptric, especially where it is required to illumine the whole circle 360 degrees. Over an arc too, according to its area, it has the power of intensifying the light, by utilizing it where not required, and returning it, from where it would otherwise be wasted by reflectors and refractors, to strengthen the illuminated arc; and it has also a great advantage over the reflector in its facilities for marking channels or outlying dangers, which is done by placing a sector of coloured glass vertically on the lens, in conjunction with one on the lantern glass, in line with the danger to be marked; and this can be done with an accuracy impossible in a catoptric light.

In a Dioptric Revolving Light—the panels of glass usually range from eight to sixteen in number; but occasionally there are only six sides or panels, which produce a very powerful flash, by concentrating a larger arc of light.

Apparent Lights.

The apparent light is an ingenious and very useful contrivance, by which beacons marking sunken rocks lying off lighthouses may be illuminated from the lighthouse, by reflection from an apparatus hermetically sealed, placed on top of the beacon. The apparatus consists of a plane mirror, upon which the rays of light from the special light placed in a window in the lower part of the lighthouse, on a level with the beacon apparatus, impinge; the reflected rays being strengthened by passing through glass prisms. This contrivance was first introduced by Mr. T. Stevenson, C.E., at Stornoway, in the Hebrides, to illuminate the beacon on the Arnish Rocks. These rocks are distant 530 feet from the lighthouse on Arnish Point.

The apparent light has since been applied at Odessa, and also at Port Curtis in Queensland.

Definitions of Lights.

F.—Fixed or steady. The fixed white light may be taken as the normal type, with the special advantage, when dioptric, of affording a sharp cut if wanted (which cannot be obtained with a revolving light), but with the drawback of relative weakness in power, and of confusion with riding lights or stationary lights on shore.

Fl.—Flashing. Showing flashes at short intervals, or groups of flashes at regular intervals.

F. and Fl.—Fixed and Flashing. Fixed light with addition of white or coloured flashes preceded and followed by a short eclipse.

Rev.—Revolving Light, gradually increasing to full effect, then decreasing to eclipse. (At short distances and in clear weather a faint continuous light may be observed.) No light on the English coast is withdrawn for more than one minute forty-five seconds (two minutes time—fifteen seconds flash, one minute forty-five seconds darkness), whilst some repeat the flashes as quickly as every ten seconds.

Int. or Occ.—Intermittent or Occulting. A light suddenly and totally eclipsed for a short interval.

These are in effect the reverse of revolving lights; in which the period of visibility is short, and that of darkness long; but in the intermittent or occulting light, the light is long and the eclipse of it short.

When the light between the eclipses is visible more than thirty seconds the term *intermittent* is applied; if less, it is termed *occulting*.

Alt.—Alternating. Light showing red and white, or green and white, alternately, at equal intervals, and without any intervening eclipse.

BUOY SYSTEMS.

System of Buoyage in use by the Corporation of Trinity House, in Buoying New Channels.

The side of the channel is to be considered starboard, or port, with reference to the *entrance* to any port *from* seaward.

The entrances of channels, or turning points, shall be marked by conical buoys with or without staff and globe, or triangle, cage, etc.

Single-coloured can-buoys, either black or red, will mark the *starboard* side, and buoys of the same shape and colour, either chequered or vertically striped with white, will mark the *port* side; further distinction will be given, when required, by the use of conical buoys with or without staff and globe, or cage; *globes* being on the *starboard* hand and *cages* on the *port* hand.

Where a *middle* ground exists in a channel, each end of it will be marked by a buoy of the colour in use in that channel, but with horizontal rings of white, and with or without staff and diamond, or triangle, as may be desirable; in case of its being of such extent as to require intermediate buoys, they will be coloured as if on the sides of a channel. When required, the outer buoy will be marked by a staff and diamond, and the inner one by a staff and triangle.

Wrecks will still continue to be marked by green nun-buoys; light vessels or other craft anchored to mark the position of wrecks have their top sides coloured green, and exhibit two balls placed horizontally on a yard by day, and two white fixed lights placed horizontally by night.

All lightships and buoys have their names painted on them in conspicuous letters.

System of Buoyage in use by the Commissioners of Irish Lights.

The side of the channel is to be considered starboard or port, with reference to the *entrance* to any port *from* seaward.

Single-coloured buoys, *black* on the starboard, and *red* on the port, mark the sides of channels.

The entrances to channels are marked by conical buoys with or without staff and globe.

The extremities of banks are marked with conical buoys, the north or seaward end with staff and globe, and the southward or landward end without. Sides of banks are marked by can-buoys. The colour of all these buoys depends on the locality with reference to other buoys already existing.

Wrecks are marked by green nun-buoys; or light vessels on the Trinity House system.

System of Buoyage in use by the Commissioners of Northern Lighthouses.

No.	Distinctive Colour of Buoy.	Purpose to be served.	Directions for entering Port.
1.	Red.*	Bounding main channel.	Keep on starboard hand.
2.	Black.*	Bounding main channel.	Keep on port hand.
3.	Black and red chequered.	Marking small central dangers.	Pass on either hand.
4.	Red and white chequered.	Bounding port side of large central dangers across the channel.	Keep on starboard hand.
5.	Black and white chequered.	Bounding starboard side of large central dangers across the channel.	Keep on port hand.
6.	Red and white vertical stripes.	Bounding upper end of large central dangers up and down the channel.	Pass on either hand as 3.
7.	Black and white vertical stripes.	Bounding lower end of large central dangers up and down the channel.	Pass on either hand as 3.
8.	In horizontal belts of colour, with the word "Fairway" on it.	Fairways— Black and white—port fairway. Black and red—centre fairway. Red and white—starboard fairway.	Pass on either hand.
9.	Green, with the word "wreck" on it.	Sunken wreck.	Pass on either hand.

* When surmounted with a perch, it indicates an elbow or turning point. Each buoy is further distinguished by the name of the danger it is intended to mark painted on the top in black letters on a white ground.

System of Buoyage as used by the Mersey Dock and Harbour Board.

ARRANGEMENT OF BUOYS.

Can-Buoys.—Red on the starboard hand when running in.

Nun-Buoys.—Black on the port hand when running in.

Buoys with perch and ball indicate elbows or turning points in channels. Each buoy bears the initial letter of the name of the channel it occupies, with a number, according to its situation reckoned from seaward, in the channel thus: Q indicates the outer buoy of the Queen's channel.

British India.

A uniform system of buoyage is being gradually introduced; it is as follows:—

The side of the channel is to be considered starboard or port, with reference to the *entrance* to any port *from* seaward.

The entrances of channels or turning points are marked by *conical* buoys with a staff carrying globe or triangle or basket—*black* buoys on starboard side of the channel, and *red* on port hand.

The sides of channels are marked by *conical* buoys, painted *black* on the *starboard* side, and *can*-buoys painted *red* on the *port* side.

Middle grounds are marked by *conical* buoys showing *red* on one side of the buoy, *black* on the other, surmounted by a *double* beacon, either of basket and globe, or basket and triangle.

Wrecks are marked by *green nun*-buoys.

Fairway buoys are *conical* and painted *chequered black* and *white*.

Isolated sunken rocks are marked by *red conical buoys*.

Canada

Is buoyed on the same system as the United States of America. See page 175.

China.

The side of the channel is to be considered starboard or port, with reference to the *entrance* to any port *from* seaward.

Buoys coloured *red* mark the *starboard* side of the channel; buoys, coloured *black* the *port* side.

Buoys painted in *red and black horizontal bands* mark the fairway, and should be passed close to.

Buoys painted in *red and black vertical* stripes mark the ends of spits and the outer and inner extremes of banks, shoals, or extensive reefs, where there is a navigable channel on either side.

Buoys painted *red and black chequered* mark rocks, or obstructions of small extent having channels on either side of them. When marking the latter, they will be placed to seaward of the danger.

When two *chequered* buoys—*red and white* and *black and white*—mark an obstruction, the *red and white* buoy marks the *starboard* side of the channel; and the *black and white* buoy marks the *port* side.

Wrecks are marked by green buoys.

Beacons are painted in the same manner as buoys.

Denmark.

The following are the regulations for buoyage in this country:—

In coming from the *north* or from the *east*, or in entering into a closed bay, buoys with red or black poles are on the starboard hand, and buoys with white poles on the port hand.

In coming from the *south* and from the *west*, white poles to starboard and red or black to port.

A pole with stripes of different colours indicates a middle ground.

Buoys are also used with poles to which is attached a *broom*, the broom being turned *downwards* on the east side of a channel, and *upwards* on the west side.

Wrecks are marked by casks or buoys painted green and surmounted by *a green flag*.

France.

Shipmasters frequenting the ports and harbours on the coast of France must observe the following rules:—

On entering a channel from seaward, all buoys and beacons painted *red* with a *white* band near the summit, must be left to starboard: those painted *black* must be left to port. Buoys that can be passed on either side are coloured *red with black horizontal bands*. That part of the beacon *below the level of high water*, and all warping buoys, are coloured *white*. The small rocky heads in frequented channels are coloured in the same way as the beacons, when they have a surface sufficiently conspicuous.

Each beacon or buoy has upon it, either at full length, or abbreviated, the name of the danger it is meant to distinguish; likewise, its number, commencing from seaward, and thus showing its numerical order in the same channel.

The *even* numbers are on the *red* buoys, and the *odd* numbers on the *black* buoys; the buoys and beacons coloured *red with black horizontal bands* are named but not numbered.

The letters and numbers are painted in *white* on the most prominent part of the buoys, and from ten to twelve inches in length.

The masts of the beacons which do not present sufficient surface are surmounted for this purpose by a small board. All the jetty heads and turrets are coloured above the half-tide level, and on the former a scale of mètres is marked, commencing from the same level.

Tide Signals.—In French ports, flood and ebb, and the height of the tide, are signalled at intervals by means of black balls, and by flags; these are hoisted on a mast crossed by a yard.

A ball at the intersection of the mast and yard indicates a depth of 3 mètres or 9¾ feet. Each ball *below* this, and in the line of the mast, represents an additional height of 1 mètre or 3¼ feet,—but each ball *above* it, an additional height of 2 mètres or 6½ feet. A ball hoisted at the yard-arm and seen to the left of the mast indicates ·25 mètres or ¾ of a foot additional; but seen to the right of the mast, ·5 mètres or 1⅔ feet additional.

In order to show the state of the tide in respect to flood and ebb, a white flag crossed with black from corner to corner, and a black pendant, will be used. One or both of these will be flying at the masthead, so long as there are two mètres or six and a half feet of water in the channel; thus, the pendant above the flag indicates flood,—the flag alone, high water,—and the pendant below the flag, ebb.

A *red* flag at the masthead indicates that the state of the tide is such that a vessel *cannot* enter.

Netherlands.

The rule is: on entering the channel, etc., from seaward, *white* buoys must be left on the *starboard* hand; *black* buoys on the *port* hand. There are certain exceptions to this rule, as at Groningen, where the colours are reversed.

Outside buoys and those indicating where the division of a channel begins are painted *red.*

Wreck buoys are either painted *green* or *chequered black and white.*

Belgium

Is buoyed on the same system as the Netherlands.

Norway.

A *white* stake with a broom turned upwards denotes that the shoal lies to the north or east of the mark.

A *black* stake with a broom turned downwards denotes that the danger lies to the south or west of the mark.

A stake with *white and black horizontal stripes* surmounted by a ball, may be passed on either side.

Russia.

The buoyage arrangements in Russia are very similar to those which are in use in Sweden and Norway; that is, the sea marks (which mostly consist of poles surmounted by different signals and varied in colour) denote the compass bearing of the danger which they are intended to mark. The sea marks are classified as follows:—

For the Open Seas.—1. A *red* broom open *upwards* on a red pole means that the danger lies to the *north.*

2. A *black* broom open *downwards* on a white pole means that the danger lies to the *south.*

3. Two *black* brooms on a black and white chequered pole means that the *danger* lies to the *east.*

4. Two *red* brooms on a red and white chequered pole means that the danger lies to the *west*.

5. A *black* pole with cross at the top and surmounted by a ball means that a vessel can pass on all sides.

The Finnish Fiords are buoyed on the same principle as above, but some of the marks differ slightly in character.

Sweden.

Sea marks placed south or west of a shoal or danger are coloured *red*; they mostly consist of a pole with a broom at the top. Those placed north or east of a shoal consist of a smooth unpainted pole. A pole with a cross at the top denotes that the shoal can be passed on all sides.

At night, the intermittent light (on Von Otter's system) is used to indicate the sailing channels, one *red* or *white* flash every *four* seconds being used to indicate the *port* side, and *two quick flashes* either *red* or *white*, with the same interval of darkness, the *starboard* side.

United States of America.

In approaching the channel, etc., from seaward, *red buoys*, with *even numbers*, must be left on the *starboard* hand in passing in, *black buoys*, with *odd numbers*, on the *port* hand.

Buoys painted with *red* and *black horizontal stripes* will be found on obstructions, with channel ways on either side of them, and may be left on either hand in passing in.

Buoys painted with *white* and *black perpendicular stripes* will be found in *mid-channel*, and may be passed close to.

All other distinguishing marks to buoys will be in addition to the foregoing, and may be employed to mark particular spots; a particular description of which will be given in the printed list of buoys.

Perches with balls, cages, etc., will, when placed, be at turning points, the *colour* and *number* indicating on what side they shall be passed.

Vessels approaching or passing Light Vessels of the United States, *in foggy, thick weather*, will be warned of their proximity by the alternate ringing of a bell and sounding of a fog-horn on board of the Light Vessel, at intervals not exceeding five minutes.

Signs and Abbreviations adopted in the Charts published by the Hydrographic Office of the Admiralty.

Quality of the bottom.		General Abbreviations.		General Abbreviations.	
b.	— blue	Alt.	— Altitude	Lt. F.	— Light Fixed
blk.	— black	Anch^{ge}.	— Anchorage	Lt. Fl.	— Light Flashing
br.	— brown	B.	— Bay	Lt. Int.	— Light Intermittent
brk.	— broken	B. (*near a buoy*)	Black	Lt. Occ.	— Light Occulting
c.	— coarse	B^{k}.	— Bank	Lt. Alt.	— Light Alternating
cl.	— clay	C.	— Cape	Lt. Rev.	— Light Revolving
crl.	— coral	C.G.	— Coast Guard	L.W.	— Low Water
d.	— dark	Cath.	— Cathedral	Mag^{s}.	— Magazine
f.	— fine	Ch.	— Church	Mag^{c}	— Magnetic
g.	— gravel	Chan.	— Channel	Min.	— Minutes
gn.	— green	Cheq.	— Chequered	Mt.	— Mountain
grd.	— ground	Col^{d}.	— Coloured	Np.	— Neaps
gy.	— gray	Cr.	— Creek	Obsn. Spot	— Observation Spot
h.	— hard	E. D.	— Existence Doubtful	P.	— Port
m.	— mud	Flg. Lt.	— Floating Light	P.D.	— Position Doubtful
oys.	— oysters	Fms.	— Fathoms	Pk.	— Peak
oz.	— ooze	Ft.	— Feet or foot	Pt.	— Point
peb.	— pebbles	G.	— Gulf	R.	— River
r.	— rock	Gt.	— Great	R. (*near a buoy*)	Red
rot.	— rotten	H.	— Hour	Rf.	— Reef
s.	— sand	Hd.	— Head	Rk.	— Rock
sft.	— soft	Ho.	— House	Sd.	— Sound
sh.	— shells	H^{r}.	— Harbour	Sec.	— Seconds
spk.	— speckled	H.S.	— Horizontal Stripes	Sh.	— Shoal
st.	— stones	H.W.	— High Water	Sp.	— Springs
stf.	— stiff	H. W. F. & C.	— {High Water / Full and change}	Str.	— Strait
w.	— white	I.	— Island	Tel.	— Telegraph
wd.	— weed	I^{s}	— Islands	Var^{n}.	— Variation
y.	— yellow	Kn.	— Knots	Vil.	— Village
		L.	— Lake	Vis.	— Visible
		Lat.	— Latitude	V.S.	— Vertical Stripes
		Long.	— Longitude	W.	— White
		Lt.	— Light	W. Pl.	— Watering Place

Conventional Signs.

Rocks with less than six feet water upon them at low water .....

Rocks awash at low water .....

Signifies no bottom found at the depth expressed ..... 70 $\frac{1}{15}$

Anchorage for large vessels .....

Anchorage for small vessels .....

Currents are represented by .....

Flood tide stream .....

Ebb tide stream .....

All charts and plans are, where practicable, constructed upon the True Meridian, *i.e.* the east and west marginal lines are drawn parallel to the true meridian. Soundings are reduced to mean low water of ordinary spring tides, and are expressed in fathoms and fractions of a fathom, or in feet and fractions of a foot, such being denoted under the title of the chart.

The underlined figures on the dry banks represent in feet or fathoms, either the depth over them at high water, or the heights of the banks above low water. The method adopted is stated on the title of the chart.

The velocity of tide is expressed in knots and fractions of a knot; the period of the tide being shown thus:—1st Qr., 2nd Qr., 3rd Qr., 4th Qr., for 1st, 2nd, 3rd, and 4th quarters. The rise of tide is measured from the mean low water level of ordinary springs. The range of tide is measured from the low water of one tide to the high water of the following tide. All heights are given in feet above high water ordinary springs, and in places where there is no tide, above the level of the sea. All bearings, including the direction of winds and currents, are magnetic, except when otherwise expressed. Bearings of lights are given as seen from seaward, and not from the lights.

The natural scale, or the proportion which the chart bears to the earth (obtained by reducing the number of feet in the minute of latitude to inches, and dividing the product by the scale), is represented thus, $\frac{1}{72150}$.

A cable's length is assumed to be the tenth part of a sea-mile.

Quality of Bottom.

AS EXPRESSED ON CHARTS OF DIFFERENT NATIONS.

English.	French.	Italian.	Spanish.	German.
Clay ... *cl.*	Argile ... *A.*	Argilla.	Arcillo or Barro	Lehm ... *L.*
Coral ... *crl.*	Corail ... *Cor.*	Corállo.	Coral ... *cl.*	Korallen ... *K.*
Gravel ... *g.*	Gravier ... *Gr.*	Rena or Ghiaja.	Cascájo ... *Co.*	Grob sand *g.s.*
Mud ... *m.*	Vase ... *V.*	Fango.	Fango or Luno *F.*	Schlemm *Sch.*
Rock ... *rk.*	Roche ... *R.*	Roccia.	Piedra or Roca *P.*	Fels ... *F.*
Sand ... *s.*	Sable ... *S.*	Sábia or Aréna.	Arena ... *A.*	Sand ... *S.*
Shells ... *sh.*	Coquille ... *Coq.*	Conchiglia.	Conchuela *ca.*	Muschel ... *M.*
Stones ... *st.*	Pierre ... *P.*	Pietre.	Piedra ... *P.*	Stein.
Weed ... *wd.*	Herb ... *H.*	Alga.	Alga ... *A.*	Gras ... *G.*
Fine ... *f.*	Fin ... *fin.*	Fino.	Fina ... *f.*	Fein ... *f.*
Coarse ... *c.*	Gros ... *g.*	Grosso.	Escalroso.	Grob ... *g.*
Stiff ... *stf.*	Dure ... *d.*	Tenace.	Tenaz.	Zahe ... *Z.*
Soft ... *sft.*	Molle ... *m.*	Molle.	Muelle.	Weich ... *W.*
Black ... *blk.*	Noire ... *n.*	Nero.	Negro.	Schwarz *schw.*
Red ... *rd.*	Rouge ... *r.*	Rosse.	Roxez.	Roth.
Yellow ... *y.*	Jaune ... *j.*	Giallo.	Amarillo.	Gelb.

Meridians adopted in the Construction of Foreign Charts.

Russia, Germany, Sweden, Denmark, Norway, Holland, Austria, and the United States of America adopt the meridian of Greenwich.

France adopts the meridian of Paris, assumed to be in longitude 2° 20′ 9·4″ E. of Greenwich.

Spain adopts the meridian of San Fernando, Cadiz, assumed to be in longitude 6° 12′ 24·1″ W. of Greenwich.

The Pulkowa Observatory of St. Petersburg (sometimes referred to in Russian Charts) is assumed to be in longitude 30° 19′ 40″ E. of Greenwich.

The Royal Observatory of Naples (sometimes referred to in Italian Charts) is assumed to be in longitude 14° 14′ 42·9″ E. of Greenwich.

Soundings upon Foreign Charts expressed thus:—

			English feet.		English fathoms.
Austrian	fathom	(Klafter)	= 6·222	or	1·030
Danish and Norwegian	„	(Favn)	= 6·175	„	1·029
Dutch	„	(Vaden)	= 5·575	„	0·929
French	„	(Brasse)	= 5·329	„	0·888
French	Mètre	(Mètre)	= 3·281	„	0·547
Portuguese	Fathom	(Braca)	= 6·004	„	1·000
Prussian	„	(Faden)	= 5·906	„	0·984
Russian	„	(Сажень)	= 6·000	„	1·000
Spanish	„	(Braza)	= 5·492	„	0·915
Swedish	„	(Famn)	= 5·843	„	0·974

The Dutch "*Elle*," the Spanish, Portuguese, and Italian "*Metro*," and the French "*Mètre*," are identical.

Sometimes upon French plans of harbours the soundings are given in feet.

A *piéd usuel* = 13·124 inches, or 1·094 feet. A *mètre* is 3 *piéds*; a *piéd du roi* = 12·7896 inches. *Brasse*, = 5·329 feet, is used upon old French charts instead of mètre. Upon some Italian charts the soundings are in French *piéd*.

SPHEROIDAL TABLES.

SHOWING the length in feet of a degree, minute, and second, of latitude and longitude, with the corresponding number of statute miles in each degree of latitude, and the number of minutes of latitude, or nautical miles, contained in a degree of longitude, under each parallel of latitude.—For every degree.

From the Tables by R. C. CARRINGTON, F.R.G.S., late of the Hydrographic Office, Admiralty.

Latitude.					Longitude.				
Latitude.	Length of one degree in statute miles.	Length in feet of a			Latitude.	Length of one degree in minutes of latitude or nautical miles.*	Length in feet of a		
		Degree.	Minute.	Second.			Degree.	Minute.	Second.
0°	68·704	362755·6	6045·93	100·77	0°	60·410	365233·7	6087·23	101·454
1°	68·704	362756·7	6045·94	100·77	1°	60·400	365178·4	6086·31	101·438
2°	68·704	362760·1	6046·00	100·77	2°	60·373	365012·7	6083·54	101·392
3°	68·706	362765·7	6046·09	100·77	3°	60·326	364736·5	6078·94	101·316
4°	68·707	362773·6	6046·23	100·77	4°	60·261	364350·0	6072·50	101·208
5°	68·709	362783·6	6046·39	100·77	5°	60·177	363853·2	6064·22	101·070
6°	68·711	362795·9	6046·60	100·78	6°	60·074	363246·3	6054·11	100·902
7°	68·714	362810·4	6046·84	100·78	7°	59·954	362529·5	6042·16	100·703
8°	68·717	362827·1	6047·12	100·79	8°	59·814	361703·0	6028·38	100·473
9°	68·721	362846·0	6047·43	100·79	9°	59·656	360767·0	6012·78	100·213
10°	68·725	362866·9	6047·78	100·80	10°	59·480	359721·7	5995·36	99·923
11°	68·729	362890·1	6048·17	100·80	11°	59·285	358567·6	5976·13	99·602
12°	68·734	362815·2	6048·59	100·81	12°	59·072	357304·8	5955·08	99·251
13°	68·739	362942·5	6049·04	100·82	13°	58·841	355933·9	5932·23	98·871
14°	68·745	362971·8	6049·53	100·83	14°	58·592	354455·1	5907·59	98·460
15°	68·751	363003·1	6050·05	100·83	15°	58·325	352868·8	5881·15	98·019
16°	68·757	363036·3	6050·61	100·84	16°	58·040	351175·7	5852·93	97·549
17°	68·764	363071·4	6051·19	100·85	17°	57·737	349376·0	5822·93	97·049
18°	68·771	363108·4	6051·81	100·86	18°	57·416	347470·5	5791·18	96·520
19°	68·778	363147·3	6052·46	100·87	19°	57·077	345459·5	5757·66	95·961
20°	68·786	363187·9	6053·13	100·89	20°	56·722	343343·7	5722·40	95·373
21°	68·794	363230·2	6053·84	100·90	21°	56·348	341123·7	5685·40	94·756
22°	68·801	363274·3	6054·57	100·91	22°	55·958	338800·1	5646·67	94·111
23°	68·810	363320·0	6055·33	100·92	23°	55·550	336373·6	5606·23	93·437

* The figures in this column, divided by 6, will give the length, in cables, of a minute *of* longitude in its corresponding latitude, thus: in latitude 23°, 55·550 ÷ 6 = 9·26 cables in *a minute of longitude.*

Latitude.	Length of one degree in statute miles.	Length in feet of a		
		Degree.	Minute.	Second.
24°	68·819	363367·2	6056·12	100·94
25°	68·828	363416·0	6056·93	100·95
26°	68·838	363466·2	6057·77	100·96
27°	68·848	363517·9	6058·63	100·98
28°	68·858	363570·8	6059·51	100·99
29°	68·868	363625·0	6060·42	101·01
30°	68·879	363680·5	6061·34	101·02
31°	68·889	363737·1	6062·29	101·04
32°	68·900	363794·8	6063·25	101·05
33°	68·912	363853·5	6064·23	101·07
34°	68·923	363913·1	6065·22	101·09
35°	68·934	363973·6	6066·23	101·10
36°	68·946	364034·9	6067·25	101·12
37°	68·958	364096·8	6068·28	101·14
38°	68·970	364159·5	6069·33	101·16
39°	68·982	364222·6	6070·38	101·17
40°	68·994	364286·3	6071·44	101·19
41°	69·006	364350·4	6072·51	101·21
42°	69·018	364414·9	6073·58	101·23
43°	69·030	364479·6	6074·66	101·24
44°	69·042	364544·4	6075·74	101·26
45°	69·055	364609·4	6076·82	101·28
46°	69·067	364674·4	6077·91	101·30
47°	69·079	364739·3	6078·99	101·32
48°	69·092	364804·1	6080·07	101·33
49°	69·104	364868·6	6081·14	101·35
50°	69·116	364932·9	6082·22	101·37
51°	69·128	364996·8	6083·28	101·39
52°	69·140	365060·2	6084·34	101·41
53°	69·152	365123·1	6085·39	101·42
54°	69·164	365185·4	6086·42	101·44
55°	69·176	365247·0	6087·45	101·46
56°	69·187	365307·9	6088·47	101·47
57°	69·198	365367·9	6089·47	101·49

Latitude.	Length of one degree in minutes of latitude or nautical miles.*	Length in feet of a		
		Degree.	Minute.	Second.
24°	55·125	333845·0	5564·08	92·735
25°	54·684	331214·9	5520·25	92·004
26°	54·225	328484·1	5474·74	91·245
27°	53·751	325653·4	5427·56	90·459
28°	53·259	322723·6	5378·73	89·645
29°	52·751	319695·6	5328·26	88·804
30°	52·228	316570·3	5276·17	87·936
31°	51·688	313348·5	5222·48	87·041
32°	51·133	310031·2	5167·19	86·119
33°	50·562	306619·5	5110·33	85·172
34°	49·976	303114·2	5051·90	84·198
35°	49·375	299516·4	4991·94	83·199
36°	48·758	295827·2	4930·45	82·174
37°	48·127	292047·7	4867·46	81·124
38°	47·481	288178·9	4802·98	80·050
39°	46·821	284222·0	4737·03	78·951
40°	46·146	280178·2	4669·64	77·827
41°	45·459	276048·7	4600·81	76·680
42°	44·757	271834·7	4530·58	75·509
43°	44·042	267537·5	4458·96	74·316
44°	43·313	263158·3	4385·97	73·100
45°	42·571	258698·4	4311·64	71·861
46°	41·817	254159·2	4235·99	70·600
47°	41·050	249541·9	4159·03	69·317
48°	40·270	244848·2	4080·80	68·013
49°	39·479	240079·2	4001·32	66·689
50°	38·676	235236·5	3920·61	65·343
51°	37·861	230321·4	3838·69	63·978
52°	37·035	225335·5	3755·59	62·593
53°	36·198	220280·3	3671·34	61·189
54°	35·350	215157·2	3585·95	59·766
55°	34·492	209968·0	3499·47	58·324
56°	33·623	204714·0	3411·90	56·865
57°	32·745	199396·9	3323·28	55·388

* The figures in this column, divided by 6, will give the length, in cables, of a minute of longitude in its corresponding latitude, thus: in latitude 51°, 37·861 ÷ 6 = 6·31 cables in a minute of longitude.

Latitude.	Length of one degree in statute miles.	Length in feet of a		
		Degree.	Minute.	Second.
58°	69·210	365427·0	6090·45	101·51
59°	69·221	365485·1	6091·42	101·52
60°	69·231	365542·2	6092·37	101·54
61°	69·242	365598·1	6093·30	101·56
62°	69·252	365652·9	6094·22	101·57
63°	69·263	365706·4	6095·11	101·59
64°	69·272	365758·5	6095·98	101·60
65°	69·282	365809·3	6096·82	101·61
66°	69·291	365858·6	6097·64	101·63
67°	69·300	365906·4	6098·44	101·64
68°	69·309	365952·7	6099·21	101·65
69°	69·318	365997·3	6099·96	101·67
70°	69·326	366040·2	6100·67	101·68
71°	69·333	366081·3	6101·36	101·69
72°	69·341	366120·7	6102·01	101·70
73°	69·348	366158·2	6102·64	101·71
74°	69·355	366193·9	6103·23	101·72
75°	69·361	366227·6	6103·79	101·73
76°	69·367	366259·6	6104·32	101·74
77°	69·373	366289·1	6104·82	101·75
78°	69·378	366316·7	6105·28	101·75
79°	69·383	366342·3	6105·71	101·76
80°	69·387	366385·8	6106·10	101·77
81°	69·391	366387·1	6106·45	101·77
82°	69·395	366406·3	6106·77	101·78
83°	69·398	366423·2	6107·05	101·78
84°	69·401	366438·0	6107·30	101·79
85°	69·403	366450·5	6107·51	101·79
86°	69·405	366460·7	6107·68	101·79
87°	69·407	366468·7	6107·81	101·80
88°	69·408	366474·4	6107·91	101·80
89°	69·409	366477·9	6107·97	101·80
90°	69·409	366479·0	6107·98	101·80

Latitude.	Length of one degree in minutes of latitude or nautical miles.*	Length in feet of a		
		Degree.	Minute.	Second.
58°	31·856	194018·3	3233·64	53·894
59°	30·958	188579·9	3143·00	52·383
60°	30·051	183083·3	3051·39	50·856
61°	29·135	177530·1	2958·84	49·314
62°	28·211	171922·1	2865·37	47·756
63°	27·278	166261·0	2771·01	46·184
64°	26·337	160548·6	2675·81	44·597
65°	25·388	154786·3	2579·77	42·996
66°	24·432	148976·3	2482·94	41·382
67°	23·468	143120·2	2385·34	39·756
68°	22·498	137219·7	2287·00	38·116
69°	21·521	131276·7	2187·95	36·466
70°	20·538	125293·2	2088·22	34·804
71°	19·548	119270·7	1987·85	33·131
72°	18·553	113211·4	1886·86	31·448
73°	17·553	107116·9	1785·28	29·755
74°	16·547	100989·1	1683·15	28·053
75°	15·536	94830·1	1580·50	26·342
76°	14·521	88641·6	1477·36	24·623
77°	13·502	82425·6	1373·76	22·896
78°	12·478	76184·0	1269·73	21·162
79°	11·451	69918·8	1165·31	19·422
80°	10·421	63631·8	1060·53	17·676
81°	9·388	57325·2	955·42	15·924
82°	8·352	51000·6	850·01	14·167
83°	7·313	44660·3	744·34	12·406
84°	6·272	38506·1	638·44	10·641
85°	5·230	31939·9	532·33	8·872
86°	4·186	25563·9	426·07	7·101
87°	3·140	19179·8	319·66	5·328
88°	2·094	12789·9	213·17	3·553
89°	1·047	6395·9	106·60	1·777
90°	0·0	0·0	0·0	0·0

* The figures in this column, divided by 6, will give the length, in cables, of a minute of longitude in its corresponding latitude, thus: in latitude 84°, 6·272 ÷ 6 = 1·05 cables in a minute of longitude.

NOTE.—These tables have been calculated for every ten minutes of latitude, and are *published by J. D. Potter*, 31, Poultry, E.C.

ADMIRALTY CHARTS.

THE sailor's attention is here called to the vast amount of practical information that may be found upon the charts published by the Hydrographic Office of the Admiralty. These works of art, from the simplicity of their style, their number and large circulation, are, unfortunately for the general interests of the community, not studied with the attention they deserve. As a very slight error in the position of a light or buoy; dot, cross, or figure; might lead to the gravest disasters, every mark upon an Admiralty chart has been delineated by the Hydrographic Draughtsmen with the greatest care and consideration, and no pains are spared by these gentlemen in their endeavour to attain, where it is possible, mathematical exactness, and to lay before the public the labours of the nautical surveyors, explorers, and amateurs, not only of England, but of the civilized world; reducing their various styles into a comprehensive system, and thus furnishing the intelligent seaman with an intelligent guide, which common industry will soon enable him to thoroughly appreciate and take advantage of.

The Admiralty Charts, which number over 2600,* are published with a view of meeting the wants of the sailor in all parts of the world. They may be classed under five heads, viz.: Ocean, General, and Coast Charts; Harbour Plans, and Physical Charts. The Ocean and General Charts are all compiled and drawn in the Hydrographic Office, and as all original documents and existing charts have to be consulted, considerable experience is required in their compilation; many matters of detail must necessarily be omitted, and the talent of the draughtsman is required to decide what to reject, what to insert, and also to arrange the names in such a manner, that while full information is given, the various straits and passages delineated shall at once catch the eye, and not be blocked up by printing.

The Coast Charts and Plans of Harbours are published from MSS. Charts forwarded to the Admiralty by their Nautical Surveyors. The greatest care is bestowed on these charts and plans in order to give prominence to all shoals and dangers, to give every possible information relating to Lights, Buoys, and Tides; the prominent features and height of the land, and above all, to the *Soundings* and nature of the bottom. For this purpose the Hydrographic abbreviations, of which a full list has just been given, are used, and the sailor is earnestly requested to make himself familiar with them so that he may have no difficulty in reading the chart.

* *See* Catalogue of Admiralty Charts; also, Index Charts, A to P; sold by J. D. Potter, 31, Poultry, E.C.—N.B. The Admiralty Charts are always corrected up to date for the latest changes in lights and buoys; the date of correction being noted at the foot of the charts.

As a large portion of the world is still *unsurveyed*, charts of such localities are drawn in a light and unfinished manner, so that the educated sailor may at once see that less trust is to be reposed upon them. It is necessary, therefore, in using the Admiralty charts to observe the date of their publication, and then to examine with care the style in which the coast line is drawn, the amount of soundings, and any notations that may be made. By this means it will be seen whether the coast in question has ever been properly surveyed, and how much reliance is to be placed upon the chart.

The Physical Charts are attempts to carry out the work so well begun by Maury of the United States, and Fitzroy of our own navy, and to give the sailor in all parts of the world a good general idea of the ocean winds at the different times of the year; the tracks and seasons of the tropical storms; the winds he may experience on nearing the coasts; the times of the rainy seasons; localities in which ice may be fallen in with; and lastly, the direction and force of the stream and drift currents of the ocean. These charts place before the sailor who is new to the waters he may be sailing on, the experience afforded by many hundred cases, enabling him to form a correct judgment as to the winds and currents that may be expected.

On arriving off ports that are difficult of access, although the chart may be a very good one, a pilot, if available, and circumstances permit, should be taken. The difficulties generally disappear after a first visit, but until the *local knowledge* necessary for the safe navigation of his vessel has been acquired, the sailor should not decline the assistance of the Pilot.

GENERAL HYDROGRAPHIC INFORMATION.

THE sailor has often the opportunity of giving considerable assistance to his fellow seamen, by forwarding to the Admiralty, Board of Trade, or Lloyds, information from which the existing charts and sailing directions may be added to, or corrected. The following suggestions of "What to observe," and "How to report," may be found useful.

The language of such communications should be simple, concise, seamanlike, and descriptive of such matters as the wants of a sailor are likely to require; as the appearance of the coast on making the land, with its prominent headlands and mountain peaks, giving their estimated height, and the distance from which they can be seen; or, if the coast be low, describing remarkable trees, conspicuous sand-hills, or any natural or artificial beacons that may help to distinguish the locality; the outlying dangers, with means of clearing them, and the general character of the soundings, with the *nature* of the bottom.

Give information as to where pilots are to be obtained; the special signals, pilot regulations and charges. Where to get steam tugs. In case of bad weather, the best anchorage or the nearest harbour of refuge to run for; or in an extreme case, as a leak, etc., describe the best place to lay the ship aground, and the best time of tide for doing so. Describe all lights, buoys, and beacons, and notice any convenient creeks or rivers for wooding or watering.

Give general directions for sailing, steaming, or working, by day, by night, and in a *fog*. State the prevailing winds and their seasons; land and sea breezes where they exist. Time balls, tide signals, and *fog* signals, are to be described. Currents to be noted, and whether permanent, or affected by periodical winds. When rivers of any importance are visited, give the points to which the tide reaches, and to which they are navigable, with the velocity of the stream at ebb and flood, and how it may be affected by periodical rains.

In describing seaports, especially those subject to changes from increased commerce, give so much of nautical statistics as will enable seamen to judge of their importance, and probable supplies that can be obtained; as—Where fresh water is to be found, in what manner, with its quality. Facilities for coaling a steamer, and price of coal. How coals are obtained, and if from a near or distant locality. Whether wood can be procured in quantity sufficient for steaming purposes or to combine with coal. Any special custom-house regulations; holidays, etc. Dock accommodation, both floating and graving. Width of entrance gates. Depth over sill at high water. Patent slip? Gridiron? Facilities for repair of a vessel, in wood and iron; or the machinery of a steamer. Conveniences for heaving down. Power of largest crane or sheers. Quarantine regulations. Hospitals or homes for sailors. Shipping office for seamen. Prevailing diseases, if of a virulent character; seasons at which they may be expected, and brief precautions for guarding against them. Diet, clothing, etc. National prejudices. Current money and its usual value in English money. Population; number of fishermen and seafaring men. Foreign consuls or vice-consuls. Means of communication by steam vessels, by rail, by electric telegraph, etc.

Tides.—For both springs and neaps give the height of high water above the level of low water ordinary springs. The times and heights of high and low water should be taken when the moon passes the meridian of the place between $11^h.$ and $2^h.$, and also between $6^h.$ and $8^h.$ In describing tide-streams in the offing, caution must be observed in not confusing the "flood" and "ebb" streams; it is rather desirable to give the direction, using the

terms "east-" or "west-going stream," as the case may be. If the tides are practically affected by diurnal inequality it should be especially noticed.*

Currents.—In general, during a passage, the difference between the position as determined by observation and that deduced from the dead reckoning has been adopted as the effect of a single current acting throughout the twenty-four hours; whereas it is probable that in some parts of the ocean where the vessel may be crossing the boundaries of opposing currents, during the twenty-four hours the ship will have passed through different streams and have been affected by different impulses. To form consistent views on a subject so necessary in every voyage, and so deeply interesting when considered on a more extensive scale, it is desirable in such cases (or where ripplings, discoloured water, flocks of birds, or shoals of fish are observed) that systematic observations for latitude and time should be made at different hours of the day or night, taking advantage especially of the clear horizon an hour before sunrise and after sunset, to obtain stellar observations, for the express purpose of apportioning the whole error of the day's work into its most likely periods. In determining the amount and velocity of an ocean current, due consideration should be given to the probable effects of any bad steerage; to the action of the swell and sea upon the vessel; and also to any changes in the variation and deviation of the compass.

Trade Winds and Monsoons.—The annual periods and geographical limits of the trade winds, monsoons and rains, and the times and local peculiarities of the daily sea and land breezes, afford ample scope for observation on many stations to the zealous officer. Observations, especially on the hurricanes or revolving storms of the Atlantic and Indian Oceans, and the typhoons in the China Sea, are also much required.

Lights.—Lights and lighthouses claim particular attention. Every detail that can be useful to the mariner should be obtained; and in describing a new light, give its character and brilliancy; the intervals of its flashes, if revolving; whether the illuminating apparatus be dioptric or catoptric, and its order or class; likewise the bearings from seaward on which the light is either visible or obscured, the height of the centre of the lantern above the high water of ordinary spring tides, the height also of the building from the base to vane, its form, colour, or other pecularity.

In case of a new light, or error in description of an old light, it should be immediately reported to the Admiralty, Board of Trade, or Lloyds, by special

* This feature in tidal phenomena has not received the attention it merits. In most parts of the globe the diurnal inequality will be found to be a regular change, considerable in *amount*, and almost universal in prevalence.—*See* "Tides."

letter, in order that the correction may be made in the published List of Lighthouses.

Vigias.—Numerous imaginary dangers are traditionally inserted in all ocean charts, and from which they might be expunged if ample evidence of their non-existence within wide limits of their alleged positions could be obtained. Pieces of wreck, fish, dirty icebergs, trunks of trees, and dead whales, account for most of these reported rocks. In the neighbourhood of such imagined dangers, a few deep-sea casts of the lead would be well bestowed, and the observant seaman will keep his eyes open to every unusual appearance in the sea, such as partial ripplings, discoloured water, flocks of birds, or shoals of fish, as they may, if not caused by the meeting of opposing currents, be indications of some change in the nature or depth of the bottom; in all such cases a deep-sea cast should be obtained.*

Variation of Compass.—As the lines of equal variation traced on a chart are valuable to seamen, not only for the ordinary purposes of navigation, but also to determine by comparison the varying error of their compasses, pains should be bestowed in multiplying observations at sea for the variation of the compass, more especially when the track of the vessel passes through those spaces where the variation changes rapidly, as off the coast of Newfoundland and Nova Scotia. These observations should be tabulated, with the date, ship's position, direction of ship's head, and tables of deviation of the compass as determined wholly or partially at sea or in port.

Meridian Distances.—In determining the longitudes of imperfectly known places, meridian distances well measured will be very valuable. All chronometers should, if possible, be rated by equal altitudes of the sun; and as meridian distances depend upon places the positions of which are well known, it should always be stated from what point the meridian distance was measured, the time elapsed between the rating of the chronometers, and number of chronometers used.—*See* "Chronometers." When a meridian distance is measured to a point or island on an unsurveyed coast, a rough plan of the immediate neighbourhood should also be provided.

Courses and Bearings are invariably to be given by compass, corrected for the deviation. All dangers, especially those on which a vessel has struck or grounded, are always to be determined by two or more horizontal sextant angles of well-selected objects.—*See* "Determining Positions." A careful magnetic bearing should also be given of one of the objects used. If bearings

* Considerable discretion is required in reporting new rocks or dangers. Their existence and position should first be well determined; for when once doubtful dangers are placed upon the chart, there is a great difficulty in removing them; they become a source of considerable anxiety, increasing the difficulties of navigation, harassing alike the mind of the chart-maker and the chart-user.

only are observed, care should be taken that they do not cut each other at a less angle than 25°.

All Soundings taken are to be reduced to the low water level of ordinary spring tides.

When an Admiralty Chart is mentioned, gives its number and the date to which it was last corrected. If an Admiralty Pilot, or Directory, give page and edition. If the Admiralty Light List, give date of list, and number of the light.

Sailing along a coast of which there are no reliable Charts; angles, bearings, and true bearings, with astronomical obervations, should be taken to acquire some knowledge of the nature of the coast, and to correct the errors of the existing chart. On moonlight nights latitudes from altitudes of stars north and south of zenith should be obtained, with frequent observations in the northern hemisphere of the pole star. Time, or latitude, may also be found, by observing stars just before sunrise or after sunset. The dead reckoning should be carefully kept and carefully worked, and frequent comparisons made with the astronomical positions to determine the amount of current that may be affecting the vessel.

If circumstances permit of a coast being examined, *a true bearing* from amplitude may be obtained at sunrise, and angles measured between conspicuous objects, noting the direction of the ship's head, the course to be steered, the patent log, if in use, and the time. Another set of angles between the points used at sunrise, and *a true bearing* * from azimuth, may be taken when the forenoon observations are obtained, other objects ahead being selected to continue the work by; a third set may be taken at noon, and the observations continued on similar principles in the afternoon and evening. In thus obtaining the sets of angles and bearings for a running survey, it must be remembered that the ship must either be stopped or hove to, or the observations must be taken simultaneously. Bearings of all objects in transit should be taken, and the direction of the ship's head and her courses carefully noted. If no current has been experienced, the courses steered and distances run will form bases from which an attempt at projection may be made; or from the true positions determined by observations, the bearings may be laid off. By following the above simple directions intelligent seamen have

* Although this problem of *true bearing* is fully treated by Inman and Raper in their Navigations, it is not unfortunately in the common use that it should be among sailors. It consists in simply measuring the angular distance between the sun's limb and the object of which the true bearing is required. This angle reduced to the horizontal angle by right-angle spherics and applied to azimuth of the sun will give the true bearing of the object. The sun should be in a favourable position for taking an azimuth, and the angular distance *measured should* always be double the altitude of the sun.

frequently been able to make valuable additions to existing charts, and rough work of this description is always most acceptable to the Admiralty, and infinitely more valuable than finished drawings, that may or may not be founded on facts. In forwarding such useful information sailors and others are recommended to imitate the style of a modern Admiralty chart, of some coast or harbour similar in character to that which they may be reporting upon; so as to delineate their labours on the same system as that adopted by the Hydrographic Office of the Admiralty.

SOUNDING.

SOUNDING is especially work for a sailor, requiring all the ready wit and tact of his profession. In sounding, the sailor has to manage air and water, the rise and fall of the tides, the velocity of currents, and to fit in his work to suit wind and weather; these forces becoming firm allies to the man who studies them, and foes only to him who knows not how to use them.

This important part of a sailor's duty has hitherto hardly met with the attention it deserves; to the naval officer it is of the utmost value. To be able to obtain accurately the depth of water, and then to place the soundings so taken in their true positions upon the chart, allowing for the rise and fall of the tide, will make an officer not only useful in peace, but terrible in war. Prior to the battle of Copenhagen the boats of the fleet were occupied for a day and a night in taking the necessary soundings, and laying down new buoys in lieu of those which had been taken away. Nelson, fully aware of the difficulties before him, personally assisted in this laborious and important duty, taking no rest until it was accomplished. A study of the life of England's greatest sailor will show that no part of his profession was beneath his notice. Nelson was not only an Admiral—he was also a Pilot!

A vessel may, at times, be anchored in a bay or off a coast of which no chart exists; in this case it may be considered necessary, not only to sound round the ship, but to be able to make some report upon the anchorage. If, therefore, time does not admit, or inability prevents, a regular survey of the place being made, some idea of its form, extent, and depth of water may be arrived at by simply running lines of soundings from the ship, anchored near the centre, to the prominent points of the coast, fixing these points by noting, at or near them, the masthead angle of the ship (taken both on and off the arc of the sextant), and the compass bearing of the ship.*

* If shoals are discovered in harbours or roadsteads, or upon coasts where the chart furnishes the sailor with reliable points upon the shore, the soundings should, in such cases, be fixed by sextant angles taken to such points. Sounding by masthead angle should only be

In such a case a *flag or black ball* should be hoisted close up to the ship's main truck, to facilitate the taking of the masthead angle, and the following practical hints on sounding may be found useful.

The instruments, by the help of which the important operation of sounding is carried on, are the sextant and lead line.

The Sextant, a now common but no less invaluable instrument, the inventor of which may be looked upon as one of the greatest benefactors to mankind, might be considered by the sailor as the tongue of his profession, without which he would be, to a certain extent, dumb, and able only indistinctly to give utterance to his discoveries.

The sailor should therefore lose no opportunity of making himself thoroughly conversant with this useful instrument, understanding all its adjustments, peculiarities, causes of error, the size of angles to be safely measured with it, and the means of re-quicksilvering its reflectors.* With the assistance of the sextant, Captain Moriarty found the lost end of the Atlantic cable, and without it no ocean can be properly sounded or telegraph cable fairly laid.

When in port, lying at anchor, a simple exercise in using the sextant is to take a round of angles, consisting of six or more, between distinctly seen objects lying nearly in the same horizontal plane, and see how near in addition they may be brought to 360°. Handle the sextant both ways, inverted as well as direct; many objects from being indistinct cannot be reflected from right to left, and the left-hand object that can be reflected must in such cases be used.

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used if no reliable positions can be found, or if time does not permit of making a rough triangulation of the place. The necessary geometry for fixing the soundings by sextant angles will be found under the head of "Determining Positions." Sailors who may wish to gain a further insight into Practical Nautical Surveying, are referred to a small work on that important subject, by Commander Thomas A. Hull, R.N., late Superintendent of Admiralty Charts; published at 2*s.* by J. D. Potter, 31, Poultry, E.C.

* Admiral Sir E. Belcher gives the following detailed directions for re-silvering sextant glasses when injured by damp or wet:—

"The requisites are clean tinfoil and mercury—a hare's foot is handy. Lay the tinfoil, which should exceed the surface of the glass by a quarter of an inch on each side, on a smooth surface (the back of a book), rub it out smooth with the finger, add a bubble of mercury about the size of a small shot, which rub gently over the tinfoil until it spreads itself and shows a silvered surface; gently add sufficient mercury to cover the leaf, so that its surface is fluid. Prepare a slip of clean paper the size of the tinfoil. Take the glass in the left hand, previously well cleaned, and the paper in the right. Brush the surface of the mercury gently to free it from dross. Lay the paper on the mercury, and the glass on it. Pressing gently on the glass, withdraw the paper. Turn the glass on its face, and leave it on an inclined plane to allow the mercury to flow off, which is accelerated by laying a strip of tinfoil as a *conductor* to its lower edge. The edges may, after twelve hours' rest, be removed. In twenty-four give it a coat of *varnish*, made from spirits of wine and red sealing-wax."

Every opportunity should be taken of fixing the ship on the chart by bearing and angle. Taking it for granted that the harbour in which the vessel is anchored is well surveyed, it is good practice to take angles to the different points, peaks, and islets, and laying the same off from the ship's position, to see if they agree with those on the chart. True bearings of objects, both right and left of the sun, should be frequently observed, taking care that the angle measured between the sun and the object is always double the altitude of the sun.

If angles are taken between two objects close to each other, care should be taken that they are on the same level, or that the angle measured is nearly horizontal; with large angles, it is of little consequence that the objects used are not on the same level, as the error caused by obliquity is in these cases small.

The Arc of Excess.—It is good practice to measure small angles off, as well as on the arc; the arc of excess in most sextants is 5°. Observed masthead angles will generally be less than 5°, and angles of elevation taken to peaks on making the land will always be less than 5°. Taking the angles off and on the arc, adding them together, and dividing by two, gives an angle free of index error. At sea, measuring the sun's semi-diameter, and comparing that obtained with that given in the *Nautical Almanac*, renders the observer dexterous in observing small angles with the sextant. If the object is clear and well defined, the inverting tube will be found of great assistance.

A man-of-war's man should lose no opportunity of volunteering to lay out targets in well-known harbours or roadsteads by the masthead angle, taking the angle both off and on the arc of the sextant, that being one of the methods used in nautical surveying for determining an approximate base. When the target is moored, if time permits, get a round of angles from it; these plotted on the plan of the harbour will afford an opportunity of testing the accuracy of the base obtained from the masthead angle, taking care to fix the ship's position for the way in which she may be swung, either on leaving or returning on board.

The Lead Line, by means of which the soundings are obtained, should be looked upon, and treated, as a valuable instrument, and therefore to be used for no other purpose but sounding, except in the absence of a chain for measuring a base line, or ascertaining the height of a cliff.

A good plan is to take for this purpose a ship's line that has been some little time in use, and is, therefore, well stretched, marking it when wet to feet as far as five fathoms, on the same principle that the ordinary line is marked to fathoms, with two knots at twenty feet, and a bit of leather at four

fathoms or twenty-four feet. The line should always be measured on the nails driven into the quarter-deck for that purpose, both when leaving and returning to the ship, taking care when first measured that the line is always thoroughly wet. If obliged to use a new line, and shoal water is found in sounding out a bay or roadstead, the line should be re-measured in the boat, on the boat-hook, marked to feet, for that purpose. The line should always be marked from the heel of the lead.

Men should be accustomed to heave the lead from the boats, and should be narrowly watched when first at work, in order to insure their giving the correct soundings. The foremost awning stanchion, shipped, forms a good support for the leadsman's breast-rope. Some little practice and method is required on the part of the man heaving the lead from the boat, and also on the part of the officer, to determine, first when an "up and down" cast can be obtained without laying on the oars, and secondly, when it may be necessary to stop the boat altogether.

In the boat, as in the ship, the end of the lead line should always be secured before beginning to sound, and care should be taken that a "boat's lead" is taken from the ship for this work, with the necessary tallow for arming, as the nature of the bottom should always be noted, especially marking any changes that may occur, such changes often giving warning of neighbouring shoals.

Sounding in tide-way, it may be necessary to anchor the boat to obtain the masthead, or other angles, to fix the boat's position.

Equipment of Boat.—Care should be taken in the equipment of the boat for sounding. Dockyard rigs are the best, and all fancy rigs should be avoided. A spare hand should be taken for sounding. The following is a list of the gear that will be required:—

Two leads and lines, the latter marked to feet as far as 5 fathoms, one line being 40 fathoms long; the leads, one to weigh 14 lbs., and the other 7 lbs.; a spare lead of 7 lbs.

Anchor, with cable of 30 fathoms. Yoke lines sufficiently long to allow of the boat being steered by the feet.

Bag of lime, whitewash-brush, bucket, and bailer. Slow-match. Matches. Strand of junk for stops. Old canvas or old black bags to make marks on the shore. Tallow for arming. Two 56 lbs. pigs of ballast, slung for mooring buoy. An axe and crowbar.

Boat's compass, sextant; if available, a patent log fitted, so that the box *part* may be lashed on to the gunwale of the boat, a longer fly-line being

required; note-book, sketch-book, drawing instruments, small board, tracing paper, penknife, india-rubber, haversack, telescope or binoculars, and watch.

Two barécas, one with water, and one fitted as a buoy.

The Boat's Crew.—It will be of great assistance to the officer to study the men who compose his boat's crew. Let him make himself acquainted with how far they can fairly pull in a day's sounding, exercise them in lowering and hoisting the sail, tacking and wearing, getting the mast up and down, as smartness in these matters will often give them a spell from the oars, and enable the officer readily to find the position of a shoal cast, obtained in a line of sounding.

Noting.—The soundings should be noted at equal intervals and distances. If a patent log cannot be obtained, this must be done by the judgment of the officer, by time or stroke of the oars. Under five fathoms the lead should be hove continuously, and the boat's position fixed by masthead angle of ship near the three and five fathom line at low water on approaching and leaving the land.

Reduction of Soundings to Low Water.—A space must be left underneath the figures of the soundings in the note-book, in which they may be reduced to low water of ordinary Spring Tides by a table derived from observations that *must be made* on the rise and fall of the tides while the soundings are being taken, either by means of a tide pole erected near the shore, or by watching the rise and fall with a well-marked lead-line on board the ship. (*See* page 213 for further information upon this most important subject.) The reduced soundings should be noted in red ink.

The Time should be noted whenever soundings are taken, or at least every half-hour. In the absence of a watch the signal man on board the ship should be directed to hoist a numeral flag every hour, showing the number of the bells struck, keeping the same flying for five minutes, and hoisting the dinner pendant at noon. Attention in the notation of the time is not only a great assistance to the memory when plotting the soundings on a rough plan, but without it the reduction of the soundings to low water cannot be honestly carried out.

The greatest care should be taken in entering the soundings, bearings, masthead angles, time, and other matters in the note-book in such an intelligible manner that another sailor could use them, so that in the case of accidents, common to seamen, if the note-book were saved, the work would not be lost. On return to the ship the work should be plotted as soon as possible, while the memory is green. Such precautions, adapted to the simple capacity of the industrious enable the sailor to prove beyond a doubt the correctness of

his work, and the existence of rocks, or errors in the chart, which his useful labours may have detected.

To ensure the lines sounded upon being straight lines, the ship should either be kept in transit with some object beyond her, or some well-marked object should be found on the shore in line or transit with the point or mark for which it is intended to steer, this second mark lying sufficiently far behind the point steered for to show any deviation from the straight line required. If pulling or sailing to seaward, the same should be looked for astern; such objects kept in transit *must* insure a straight line being followed; on nearing the shore a good look-out should be kept for a third object in the same line, in case of the second mark used dipping behind the foreland. Keeping the boat on known straight lines is the only sure method of sounding in a tideway. As there is some difficulty in steering by stern marks, the use of them should be made a point for practice. In all cases the compass-bearing of the points steered for or from should be noted.

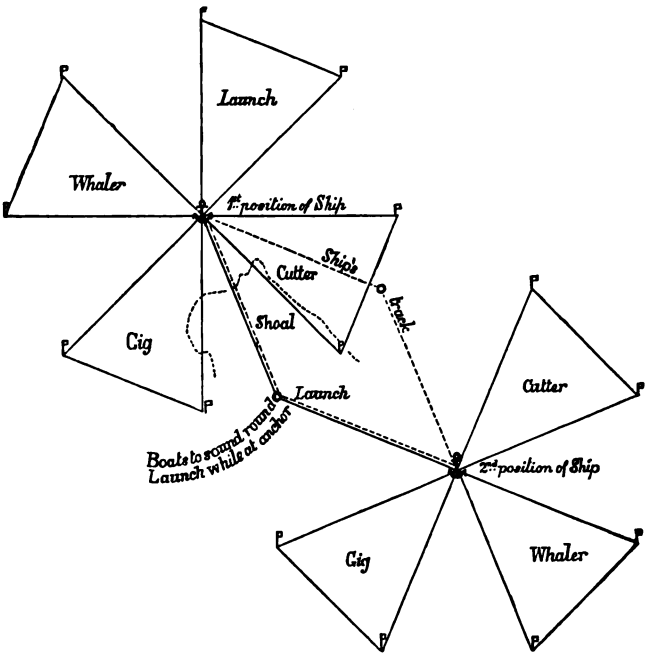
In sounding under sail five fathoms may be obtained without lowering the sail; but if the water is deeper, the sail should be lowered if running free, or the sheet eased off when sailing near the wind, to insure getting an "up and down cast."

A Baréca for Beacon should be fitted as a buoy, with a buoy rope of about ten fathoms made of lead-line, and a pig of ballast to moor it by. This will be found useful to drop upon any sunken rock that may be discovered, the boat pulling and sounding round it in all directions to find out the extent and nature of the danger, carefully noting the courses steered and, in the absence of a patent log, estimating the distances pulled from and towards the baréca.

Boat's Anchor.—In using the boat's anchor in sounding, where the boat may frequently be anchored on rocky ground, it is advisable to bend the cable like a buoy-rope to the crown of the anchor, stopping it with spun-yarn to the ring; then if the flukes jamb in the rock the stop will carry away, and the anchor may be weighed with ease. This precaution has saved many a boat's anchor, prevented a return to the ship, and the disarrangement of a well-contemplated scheme.

Gaining Local Information.—If the bay or coast to be sounded is inhabited, take pains to gain the friendship of the fishermen, as these men making their living by their knowledge of localities useful to themselves but dangerous to shipping, are often able to point out the positions of rocks or foul ground. Boats or canoes fishing should be piously avoided by a vessel coasting or entering a strange port or roadstead, as they are liable to be *working* in the vicinity of rocks or shoals.

Shoals out of sight of Land.—If a shoal is fallen in with out of sight of land, or if a ship is sent to search for and examine a danger so placed, the vessel should, on finding the shoal water, if possible, anchor, mooring if convenient. Four boats might then be sent away to sound on north, east,



south, and west lines from the ship for 2½ miles, hoisting a flag every half-hour, and taking a masthead angle of the foremast, at which truck a black ball should be hoisted, an observer at the ship at the same time taking a bearing of the respective boats. At the end of the 2½ miles, the distance

should be determined by mast-head angle; the boats will then pull respectively E.S.E., S.S.W., W.N.W., and N.N.E., for 1·9 miles, fixing their positions by mast-head angles, and hoisting their flags to allow the ship to obtain bearings of them. They will then return to the ship on S.W., N.W., N.E., and S.E. courses, sounding and hoisting their flags as before.

If shoaler water be found, requiring further or more extended examination, the launch should be sent in the direction of the foul ground to anchor on a given bearing at a distance of not over 2½ miles from the ship; a mast-head angle will be taken from the launch to determine the distance. Ship will weigh at a signal from launch, and take up a second position as convenient not more than 2½ miles from the launch, and another masthead angle will be obtained from launch when ship has anchored, and hoisted her masthead flag or ball. Launch will return to ship sounding, and the three remaining boats should sound round the ship as before.

Geographical Position of Shoal.—The ship's position at one of her anchorages should be carefully fixed by astronomical observation; the latitude being determined, if possible, by meridian altitudes of stars, north and south of the zenith. Time should be determined by equal altitudes, or by means of a.m. and p.m. sights, and a meridian distance obtained between the shoal and the nearest well-known point of land.

An approximate time of High Water at Full and Change, together with the rise and fall of the tide, may be obtained by noting the depth alongside the ship with a well-stretched lead-line, carefully marked to feet and inches. (*See* page 215.)

DEEP SEA LEAD-LINE,

(Weight of Lead 28 to 30 lbs.)

Is from 100 to 200 fathoms long, and marked the same as a hand line up to 20 fathoms, then with one knot at 25 fathoms, three knots at 30, one knot at 35, four knots at 40, and so on to 95. Then at 100 fathoms a piece of bunting, at 105 one knot, at 110 a piece of leather, at 115 one knot, at 120 two knots, and so on as in the first 100 fathoms.

LEAD-LINE.

Weight of Lead 7 to 14 lbs.: Length of Line 20 to 25 Fathoms.

Marks. Fathoms.	Deeps. Fathoms.
.....	1
2—A piece of leather with 2 strips	
3—A piece of leather with 3 strips	
.....	4
5—White	
.....	6
7—Red	
.....	8
.....	9
10—A piece of leather with a hole in it	
.....	11
.....	12
13—Blue	
.....	14
15—White	
.....	16
17—Red	
.....	18
.....	19
20—Two knots*	

* For surveying, the lead line is marked in feet up to five fathoms.

Table for converting French Mètres and Décimètres into English Feet and Fathoms.

By Robert C. Carrington, F.R.G.S., late of the Hydrographic Office, Admiralty.

1 French Mètre = 39·3708 English Inches.

Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.
0·			2·	6 1/2	1	4·	13	2 1/2	6·	19 1/2	3 1/2	8·	26 1/2	4 1/2
·1	1/2		·1	6 13/16	1 1/8	·1	13 1/2	2 1/4	·1	20	3 1/3	·1	26 15/16	4 1/2
·2	1		·2	7 1/16	1 1/8	·2	13 15/16	2 1/4	·2	20 1/2	3 1/3	·2	27 1/16	4 1/2
·3	1 1/16		·3	7 3/8	1 1/4	·3	14	2 1/3	·3	20 15/16	3 1/3	·3	27 1/2	4 1/2
·4	1 7/16		·4	7 13/16	1 1/4	·4	14 1/2	2 1/3	·4	21	3 1/2	·4	27 15/16	4 2/3
·5	1 13/16		·5	8 1/4	1 3/8	·5	14 15/16	2 1/2	·5	21 1/2	3 1/2	·5	28 1/4	4 2/3
·6	2 1/8		·6	8 9/16	1 3/8	·6	15	2 1/2	·6	21 15/16	3 1/2	·6	28 3/4	4 2/3
·7	2 9/16		·7	8 15/16	1 1/2	·7	15 1/2	2 1/2	·7	22	3 2/3	·7	29 1/8	4 5/6
·8	2 15/16		·8	9 5/16	1 1/2	·8	15 15/16	2 2/3	·8	22 1/2	3 3/4	·8	29 5/8	4 5/6
·9	3 5/16		·9	9 11/16	1 5/8	·9	16	2 2/3	·9	22 15/16	3 3/4	·9	29 15/16	4 5/6
1·	3 1/16	1	3·	9 15/16	1 5/8	5·	16 1/2	2 3/4	7·	23	3 5/6	9·	29 1/2	4 5/6
·1	3 7/16	1	·1	10 5/16	1 3/4	·1	16 15/16	2 3/4	·1	23 1/2	3 5/6	·1	29 15/16	5
·2	4		·2	10 11/16	1 3/4	·2	17	2 5/6	·2	23 15/16	3 5/6	·2	30	5
·3	4 1/16		·3	10 15/16	1 3/4	·3	17 1/2	2 5/6	·3	24	4	·3	30 1/16	5
·4	4 7/16		·4	11	1 3/4	·4	17 15/16	3	·4	24 1/2	4	·4	30 1/2	5
·5	5		·5	11 1/2	1 7/8	·5	18	3	·5	24 15/16	4	·5	31	5 1/6
·6	5 1/16		·6	11 13/16	1 7/8	·6	18 1/2	3	·6	24 15/16	4	·6	31 1/16	5 1/6
·7	5 7/16		·7	12	2	·7	18 15/16	3	·7	25 1/2	4 1/6	·7	31 1/2	5 1/6
·8	5 13/16		·8	12 1/2	2	·8	19	3 1/6	·8	25 15/16	4 1/6	·8	32	5 1/3
·9	6 1/16		·9	12 13/16	2	·9	19 1/2	3 1/6	·9	25 15/16	4 1/6	·9	32 1/2	5 1/3

Table for converting French Mètres and Décimètres into English Feet and Fathoms—(*continued*).

Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.	Mètres.	Feet.	Fathoms.
10·	32¾	5½	**13·**	42½	7	**16·**	52½	8¾	**19·**	62⅓	10⅓	**22·**	72	12
·1	33	5½	·1	43	7⅛	·1	52⅝	8⅞	·1	62⅝	10⅜	·1	72⅛	12
·2	33⅛	5½	·2	43⅛	7⅛	·2	53	8⅞	·2	63	10½	·2	72¼	12
·3	33½	5½	·3	43⅜	7⅛	·3	53⅛	9	·3	63⅛	10½	·3	73	12⅛
·4	34	5⅝	·4	44	7⅜	·4	53⅜	9	·4	63⅜	10½	·4	73¼	12¼
·5	34⅛	5⅝	·5	44⅛	7⅜	·5	54	9	·5	64	10⅝	·5	73½	12¼
·6	34⅜	5⅝	·6	44⅜	7⅜	·6	54⅛	9	·6	64⅛	10⅝	·6	74	12⅜
·7	35	5⅝	·7	45	7⅜	·7	54⅜	9	·7	64⅜	10⅝	·7	74½	12½
·8	35⅛	5¾	·8	45⅛	7½	·8	55	9⅛	·8	65	10¾	·8	74¾	12½
·9	35½	5¾	·9	45½	7½	·9	55¼	9¼	·9	65¼	11	·9	75	12½
11·	36	6	**14·**	45⅝	7⅝	**17·**	55⅝	9⅛	**20·**	65½	11	**23·**	75½	12⅛
·1	36⅛	6	·1	46⅛	7⅝	·1	56	9⅜	·1	66	11	·1	75⅝	12⅝
·2	36⅜	6	·2	46½	7⅝	·2	56⅛	9⅜	·2	66⅛	11	·2	76	12⅝
·3	37	6⅛	·3	47	7⅞	·3	56⅜	9⅜	·3	66⅜	11	·3	76⅛	12⅝
·4	37⅛	6⅛	·4	47⅛	7⅞	·4	57	9⅜	·4	67	11⅛	·4	76½	12½
·5	37½	6⅛	·5	47½	8	·5	57⅛	9½	·5	67⅛	11⅛	·5	77	12¾
·6	38	6⅛	·6	47⅝	8	·6	57½	9⅝	·6	67⅜	11⅛	·6	77⅛	13
·7	38⅛	6¼	·7	48⅛	8	·7	58	9⅝	·7	67⅝	11⅛	·7	77⅝	13
·8	38½	6¼	·8	48⅛	8	·8	58⅛	9¾	·8	68¼	11⅛	·8	78	13
·9	39	6½	·9	48½	8	·9	58½	9¾	·9	68½	11½	·9	78¼	13
12·	39⅛	6½	**15·**	49	8⅛	**18·**	59	9⅞	**21·**	68⅞	11½	**24·**	78¾	13
·1	39⅜	6½	·1	49⅛	8⅛	·1	59⅛	10	·1	69¼	11⅝	·1	79	13⅛
·2	40	6⅝	·2	49⅜	8⅛	·2	59⅜	10	·2	69⅝	11⅝	·2	79¼	13⅛
·3	40⅛	6⅝	·3	50	8⅜	·3	60	10	·3	69⅜	11⅝	·3	79¾	13¼
·4	40⅜	6⅝	·4	50⅛	8⅜	·4	60⅛	10	·4	70¼	11⅝	·4	80	13⅜
·5	41	6¾	·5	50½	8⅜	·5	60⅜	10	·5	70½	11½	·5	80½	13⅜
·6	41⅛	6¾	·6	51½	8½	·6	61	10⅛	·6	70¾	11½	·6	80¾	13½
·7	41⅜	7	·7	51⅛	8½	·7	61⅛	10¼	·7	71	11½	·7	81	13½
·8	42	7	·8	51⅜	8½	·8	61⅜	10¼	·8	71⅛	12	·8	81¼	13½
·9	42¼	7	·9	52	8⅝	·9	62	10⅜	·9	71¾	12	·9	81½	13½

Sounding Machines.

Several machines have been invented to facilitate sounding; among them may be specially mentioned Massey's, Walker's and Burt's buoy and nipper; but Sir W. Thomson's invention is now in very general use in vessels belonging to the Mercantile Marine, and is invaluable as a means of obtaining the depth of water quickly and accurately without stopping the engines, or deviating from the course.

Sir W. Thomson's Sounding Machine.

The apparatus consists of a drum on which is wound about three hundred fathoms of steel pianoforte wire. This is kept at intervals between the casts in a box filled with lime water, which entirely protects the wire from rust.

A brake, partially self acting, is arranged by a cord round a groove in the circumference of the drum, with two weights attached, one of lead (3 lbs.), the other a long iron weight (56 lbs.).

When ready to take a sounding, the brake is released by holding up the heavy weight and allowing the small one to hang freely in a recess in the heavy one. This opposes a slight resistance to the wire when running out, and when the sinker reaches the bottom the brake is put on by easing down the heavy weight gradually until it is supported by the small one.

Between the sinker (which is of iron, with a hollow at the bottom to receive the arming of tallow) and the depth gauge there is a two-fathom length of *plaited* rope, and the same between the depth gauge and the wire. It is important that *plaited* rope should be used, *not twisted*.

The depth gauge consists of a brass case about two feet long, containing a glass tube coated inside with a chemical preparation; this tube is open at one end, and is placed in the brass case with the open end downwards. As the sinker descends, the increased pressure drives the water up the glass tube, and the height is registered by the mark made by the combination of the water and the coating of the tube; this mark, when applied to the graduated boxwood scale, shows at once the depth that has been reached. There is also a counter attached to the wheel that shows approximately the number of fathoms of wire run out.

The instructions sent with the apparatus are ample, and the use of this simple machine is easily learnt; but men should be drilled at it in fine weather, so as to be able to handle it readily in bad. An officer and two men can with ease take soundings in a hundred fathoms every quarter of an hour from a vessel going at any ordinary speed.

Log-Line.

Is marked with a piece of bunting at the end of the stray line.

One knot at every half-knot.

A piece of leather at the first knot.

Two knots at two knots.

Three knots at three knots, and so on.

The log-line is measured to correspond with a glass running twenty-eight seconds. When the fourteen-second glass is used, the distance on the log-line must be doubled.

To calculate the length of a knot on the log-line.

3600 secs. : 28 secs. : : 6080 ft. : required length = 47 ft. 3 in.

The log-line should be repeatedly examined, by comparing each knot with the distance between the nails, which are (or should be) placed on the quarter-deck for this purpose, at the proper distance.

The line should be wet whenever it is required to re-measure it, or to verify the marks.

When heaving the log, the log-ship should be thrown out well to leeward to clear the eddies near the wake, and in such a manner that it may enter the water perpendicularly, and not fall flat upon it; before a heavy sea the line should be paid out rapidly when the stern is rising, but when the stern is falling, as this motion slacks the line, the reel should be retarded.

The sand-glasses should frequently be tested by a good watch, as in damp weather the sand does not run freely, and sometimes hangs in the neck of the glass.

Patent Logs.

A number of patent logs have been invented—some, such as "Napier's Pressure Log," and the "Clark Russell" or "Spring Log," for showing the speed at any given moment; others for registering the miles run in certain intervals of time: of these, the best known are Massey's and Walker's; with either of these, the most convenient way of using them is to fix the dial portion on the taffrail and tow the rotator by a long drift-line.

The Walker Patent Log can easily be adapted to this arrangement by the ship's artificers.

The Kelway Electric Log is an ingenious invention for showing by electricity the distance run on one or more dials placed, as desired, in different parts of the ship. The rotator for this instrument is placed under the bottom of the ship.

TIDES.

THERE are few points of a sailor's education which require more attention than the study of that important movement of the waters, known as Tides. Although his numerous duties will not permit of an attempt at an investigation of the bewildering theories that surround the subject, still he may easily acquire the requisite knowledge to enable him to discover the rise and fall of the tides, with the direction and velocity of the tidal streams, with sufficient accuracy for all practical purposes; the knowledge of the rise and fall of one foot, or of a set of half a knot per hour, being often of invaluable service in difficulties.

The Admiralty Charts, Tide Tables, and Sailing Directions give considerable information upon this point, and on entering a new chart the sailor's early attention should be given to the tidal arrows, or to any special notes that may be made upon it. He should also remember that the soundings on Admiralty Charts are all given for the *mean low water spring tides*.*

The tide is the rising and falling of the sea, which takes place about twice a day, becoming however each day later by half an hour to an hour. The rising of the sea is called FLOOD TIDE, the falling EBB TIDE.

The tides do not always rise the same height, but every fortnight, after the new and full moon, they become much higher than they were in the alternate weeks, or after the first and last quarters of the moon. These high tides are called SPRING TIDES, and the low ones, NEAP TIDES.

Those spring tides are the highest which follow the day of new or full moon by one, two, or three days, depending on the locality; for instance, the highest tides take place on the west coast of Ireland and on the south coasts of England, three transits after the new and full moon, unless diverted by gales of wind or other extraordinary causes.

Along the east coast of England, the highest tides take place four transits after the new and full moon. In the river Thames they occur five transits after the same epoch. These differences arise from the fact that the same tide-wave which produces high water on the west of Ireland, takes half a

* The *Admiralty Manual of Scientific Inquiry* furnishes a paper on the Tides, by the Rev. Dr. Whewell, in which the subject is fully treated. There is also *Elementary Treatise on the Tides*, by the Rev. J. Pearson; and a small work, entitled *The Tides*, published under the direction of the Committee of General Literature and Education, appointed by the Society *for* Promoting Christian Knowledge, from which much useful information may be obtained

day in its progress thence to the east coast of England, and a whole day before it arrives in the river Thames.

When the moon is in perigee, or nearest to the earth, the rise and fall is sensibly increased.

The Spring tides are greater about the times of the Equinoxes, *i.e.* about the latter end of March and September, than at any other times in the year; and the Neap tides are less.

The height from low water to high water is called *the range of the tide.* On the coasts of England it is greatest at the head of the Bristol Channel, where spring tides sometimes rise forty-seven feet. In some parts of the coast the range does not exceed four feet. The times at which high water takes place are equally various. Thus, the same day that it is high water at Dover at noon, it is not high water at London until 3^h p.m., and at Hull until $7^h\ 30^m$ p.m.

The interval between the time of Transit of the Moon, and the time of high water on Full and Change days at any particular place, is termed the "Vulgar Establishment of the Port;" this being ascertained by observation, the intermediate tides can be deduced from it. The corrected or Mean Tide hour or "Establishment" is the mean of all these intervals between Full Moon and New Moon, or *vice versâ*, and may differ as much as 40^m from the "Vulgar Establishment."

The Diurnal Inequality is a feature in tidal phenomena, which, being particularly small in British waters, has not received the attention it merits from the English sailor, for in the Indian seas, and indeed in most other parts of the globe, this diurnal inequality is a regular change, considerable in amount, and almost universal in prevalence. This change depends principally upon the moon being north or south of the equator; its maximum is consequent on, but not necessarily simultaneous with, the moon's greatest declination, and the period of its vanishing corresponds in like manner with the time of the moon passing the equator.

In consequence of the diurnal inequality, it sometimes happens that the day tides are higher than the night tides, or the reverse, for many weeks together. And hence it has sometimes been stated at such places, that the day tides are always the highest, or the reverse. But this is not the rule. The rule of the diurnal inequality depends on the declination of the moon and sun. If the day tides are the highest at one time of the year, they are the lowest at another.

The diurnal inequality sometimes affects the time of high water as much as two hours, that of low water about forty minutes; at the same time a

variation of twelve inches may be observed in the height of high water, and of thirty-six inches in that of low water. Such effects are far too great to be neglected, either in the prediction of tides or the reduction of soundings.

Strong winds and the varying pressure of the atmosphere considerably affect both the times and heights of high water. Thus, in the North Sea, a strong N.N.W. gale and a low barometer raise the surface two or three feet higher than the predicted heights, and cause the tide to flow all along the coast from the Pentland Firth to London half an hour longer than the times predicted in the Tables. Easterly, S.E. and S.W. winds produce opposite effects, which will be felt as far down the Channel as Dungeness. On the contrary, at the entrance of the Channel, at Plymouth, and as far up as Portland, south-westerly winds, with a low barometer, raise the surface of the water; and north-easterly winds and a high barometer always lower it.

Tidal Streams.—Besides the acquaintance with the periods of high and low water, and the comparative height of the day and night tides, it will be necessary to observe the *direction* of the stream of flood and of ebb, and the *time* at which the stream turns; but care must be taken not to confound the time of the *turn of the tidal stream* with the time of high water. Mistakes and errors have often occurred by supposing that the turn of the tidal stream is the time of high water. But this is not so. The turn of the stream generally takes place at a different time from high water, except at the head of a bay or creek. The stream of flood commonly runs for some time, often for hours, after the time of high water. In the same way, the stream of ebb runs for some time after low water.

Tide and Half Tide.—The sailor should, therefore, be careful not to confuse himself by the words "flood" and "ebb stream," but rather to use the terms "east-" or "west-" going stream, as the case may be. In some parts of the English Channel, for example, the east-going Channel stream runs up three and four hours after it is high water by the shore in the vicinity and while the water is falling; or it is ebb tide in the harbours, while the eastern, or flood stream (as it is called), is still running to the eastward, or up Channel. This difference between the time of high water, and the time of the turning of the tidal stream, is known to pilots as "Tide and half Tide." In the same manner, in the North Sea, the north-east going stream (or ebb, as it is called) makes to the eastward two hours before it is high water at Dunkerque, Ostend, etc.

The time at which the stream turns is often different at different distances from the shore; but the time of high water is not necessarily different

at these points. The time of *slack water* is not wanted for a theory of tides, though its knowledge is otherwise of considerable importance to seamen.

With regard to the streams of flow and ebb, they are often not merely two streams running in opposite directions at different times of the tide; they sometimes turn successively in several directions, so as to go round the compass in one complete tide, either in the direction N., E., S., W. (with the sun), or N., W., S., E. (against the sun).

The tides which takes place far up deep bays, sounds, and rivers, are *later* than the tides at the entrance of such inlets, but they are not more irregular; on the contrary, the tides in such situations are often remarkably *regular*.

The tide in its progress up inlets and rivers is often much magnified and modified by local circumstances. Sometimes it is magnified so that the wave which brings the tide at one period of its rise advances with an abrupt front of broken water. This is called a *bore* (as in the Severn, the Garonne, the Amazon). Sometimes the tide is divided into two half-day tides in its progress up a river, as in the Forth in Scotland. In all cases, after a certain point, the tide dies away in ascending a river.

Information on the local peculiarities of the Tides and Tidal Streams can generally be obtained from the Admiralty Charts and Sailing Directions, which should therefore be always carefully studied for that purpose.

TIDAL STREAMS IN THE ENGLISH CHANNEL.*

In the Irish Channel experiments have shown that notwithstanding the variety of times of high water throughout the Channel, the turn of the stream over all that part which may be called the fair navigable portion of the Channel is nearly simultaneous; and that the time of the turn of the stream happens to correspond nearly with the time of high and low water on the shore at *the entrance* of Liverpool. So that it is necessary only to know the times of high and low water at that place, to determine the hour when the stream of the *tide will commence or terminate in any part of the Channel.*

As a rough general rule, in the fair way of both the Irish and English Channels a vessel will be carried nine miles by the stream in a whole tide at

* If the tidal stream is marked three knots on the chart, and it be Springs,—at first hour, allow one knot; second hour, two knots; third hour, three knots; fourth hour, two knots; fifth hour, one knot. Take one-third from each of these quantities if it be Neaps.

Springs, and about six at Neaps; but near to the land on either side, or towards the banks, the rate of the stream greatly increases, and the direction varies.

English Channel.—Off the south, south-east, and east coasts of England are two Tidal streams, known as the West and East Channel streams, running in opposite directions at the same time; they are each about one hundred and eighty miles long, and are separated by the Strait of Dover; which strait may be said to lie between a line joining Beachy Head to the river Somme on the west, and another drawn from the North Foreland to Dunkerque on the east.

The West Channel stream runs between the west end of Dover Strait and a line joining the Start to the Casquets; the East Channel stream, between the east end of Dover Strait and a line joining Lynn Wash to the Texel. These streams both set uniformly in a direction *towards* Dover while the water is rising at that place, and away from it while it is *falling*. They also run in opposite directions to the two streams outside them—viz. the stream at the mouth of the Channel, and the stream in the North Sea. For the meeting of these streams in the Strait of Dover, see page 208.

Off the mouth of the English Channel the stream, although materially influenced by the indraft and outset of the Channel, will be found running to the *northward* and *eastward* while the water is *falling* at Dover, and to the *southward* and *westward* while it is *rising* at that port.

Between a line joining the Land's End to Ushant, and a line joining the Start to the Casquets, is a mixed tide, influenced by the West Channel and offing streams. Eastward of the *latter* line is the West Channel stream, which will carry a vessel towards Dover while the water is rising there, and away from it while it is falling, so that a vessel being to the northward of Ushant about two hours after high water at Dover, might be carried by the mixed tides so as to meet the West Channel stream at its turn, and by that means have the tide in her favour for more than ten hours.

The *change* of the Channel stream does not differ materially within its fair navigable limits, so that if vessels were anchored at several distances apart in the Channel fairway between the Start and Beachy Head, they would all swing in the *same direction* nearly at the *same time*. Both flood and ebb streams turn from one hour to two hours earlier in the bights of the coast than in the offing, of which vessels should take advantage when turning to windward.

Between the Lizard and the Start, the east-going tidal Channel stream runs in general from about three hours before, to two and a half hours after,

high water by the shore at Plymouth. The west-going stream runs from three and a quarter hours after, to about two and a half hours before, high water by the shore at Plymouth.

The tides about Plymouth Sound are tolerably regular both flood and ebb; generally run each way about six hours and ten minutes at a mean. In Hamoaze the flood stream continues to run up, on spring tides, about fifteen minutes after high water at Devonport Dockyard.

Abreast of Plymouth Sound, about six miles from the land, the streams are very irregular and do not turn with the tide farther out in the offing. One hour and three-quarters before high water at the Dockyard, the stream makes to the eastward and runs about E. by S. for one hour; during the next hour it is scarcely felt, after which it turns to the southward, gradually changing to W.S.W., till the last quarter of the ebb by the shore, when it veers from W.S.W. to W.N.W. During the first three hours' flood by the shore, its direction changes from W.N.W. to N.W., when it begins to slacken, and to set about N., till at the last four and a half hours' flood it runs E. by S. as at first.

There is an outset running from S.S.E. round to S.W. by S. out of the West Bay of Portland, for about nine hours, *i.e.* from five hours before, to four hours after, high water by the shore. This stream, which forms the Portland Race, acquires such velocity as to extend far beyond Portland Bill before it turns to the eastward, leaving a strong eddy between it and the land. Having assumed its easterly course, it rushes past the pitch of the Bill at the rate of six or seven knots at springs, leaping and foaming over the broken ground of Portland Ledge with great violence.

A short distance eastward of Portland Ledge this outset is met, in the latter half of its course, at nearly right angles, by the stream, which after high water by the shore, sets for nine and a half hours to the S.W. out of the East Bay of Portland; these united streams press on towards the Shambles, which shoal they cross obliquely, running about E. with a velocity of from three to four knots.

As the strong tides in the Gulf of St. Malo will influence a vessel when near the Casquets, it is necessary to *use great caution;* for the indraught is strong into the gulf, and with a gale between N.W. and S.W. the consequences may be most disastrous. With a *falling* water at Dover, the stream curves round Cape de la Hague, and sets sharply into the gulf on both sides of the Channel Islands; but with a *rising* water it sets out of the gulf on both sides of the islands, the N.W. part sweeping round Bréhat and the Sept Isles, the N.E. part round the Casquets towards Alderney, and also

through the channels about Guernsey towards Alderney race—then round Cape Barfleur into the Baie de la Seine, taking a sweep of the French shore.

There is a considerable *indraught* on both flood and ebb into all the deep bights between Portland and the Owers; the *use of the lead* in thick weather is therefore strictly enjoined.

In the Solent, and as far to the westward as Portland, there are what are termed the *first* and *second* high waters. This double high water is probably caused by the tidal stream at Spithead, for as long as that stream runs strong to the westward the tide is kept up in Southampton Water, and there is no fall of consequence, until the stream begins to slack at Spithead; but when the stream makes to the eastward at Spithead, the water falls at Southampton. After low water, the tide rises there steadily for seven hours, which may be considered as the *first* or proper high water; it then ebbs for an hour about nine inches, at the end of which time it again commences to rise, and in about one hour and a quarter reaches its former level, and sometimes higher: this is called the *second* high water. To the mariner, the knowledge that the high water at Southampton remains nearly stationary for rather more than two hours may, in some cases, be important. Similar *first* and *second* high waters occur on either shore of the Solent, as shown in the times of high water at full and change, in the Admiralty Tide Tables.

At Spithead, the eastern stream makes about two and a half hours after high water in Portsmouth harbour, and runs seven hours S.E. by S.; and the western stream about two and a half hours before high water in the harbour, and runs five hours N.W. by N.

In Portsmouth harbour the flowing continues about seven hours, and a narrow stream runs in, fifteen or twenty minutes after high water at the Dockyard. At Springs the tide runs with a velocity of four and a quarter knots at the entrance of the harbour. From the result of three years' observations taken at the Dockyard, it appears that at high water, slack water at Springs continues for eight minutes, and at Neaps sixteen minutes.

The West and East Channel streams *meet* in Dover Strait while the water is *rising* at Dover, and *separate* while it is *falling*. The point of meeting is not, however, stationary, but moves from W. to E. between Beachy Head and the North Foreland, both on the rising and falling water. When the water at Dover begins to fall, the line of separation begins off Beachy Head. As the fall continues this line *creeps* to the E. At two hours after high water at Dover, it has reached Hastings; at three hours, Rye; and thus it travels on until low water at Dover, when it has reached the line extending from the North Foreland to Dunkerque. At this time both

West and East Channel streams are slack, but the Dover Strait tide is still running to the W.

When the water at Dover begins to *rise*, both streams have made, and set towards Dover; the East Channel stream consequently goes with the Dover Strait tide, which has not ceased running to the W., while the West Channel stream meets it, and this opposition continues throughout the rising water at Dover. The line of meeting begins off Beachy Head at low water, and gradually *creeps* to the E. as the water rises. The line of meeting of four hours before high water is nearly the same as the line of separation at two hours after high water, and so it creeps on, till about the time of high water at Dover, when the point of junction has reached the North Foreland, and the high water streams are again slack; leaving Dover Strait tide still running to the E. Within the next hour the streams have made E. and W., so that now the Dover Strait tide falls in with the East Channel stream, and travels with it, whilst it separates from the West Channel stream, dividing at Beachy Head, as at first.

Strong W. gales prolong the East stream, and retard the West stream. With such gales the streams at the Ridge Shoal have been found to run eight hours to N.E., and only four hours to S.W.

Between Dungeness and Dover, the Eastern stream runs E.N.E. from about one and a half hours before to four hours after high water at Dover; the stream then turns and sets W.S.W. nearly seven hours. Both streams have an average rate of three knots at Springs and two knots at Neaps.

On approaching Boulogne at the beginning of a rising tide, recollect that the Channel streams meet thereabouts, and *turn south* upon the French coast; so that a vessel, which on the English side would have a stream setting her straight up Channel, here encounters one on her *beam*, sweeping her down towards the French shore.

At Havre, on the French coast, the high water remains stationary for one hour, with a rise and fall of three or four inches for another hour, and only rises and falls thirteen inches for the space of three hours; this long period of nearly slack water is very valuable to the traffic of the port, and allows from fifteen to sixteen vessels to enter or leave the docks on the same tide.

In the Downs the North-eastern stream begins about one hour twenty minutes before high water at Dover, and continues to run five hours and a half; it then turns and runs in a contrary direction till two hours before the ensuing high water.*

* For further information on this important subject, and also for concise directions for the navigation of the English Channel, see *The Pilot's Handbook for the English Channel*, by Staff-Commander J. W. King, R.N.; published by J. D. Potter, Poultry, E.C.

The greatest rise and fall at Springs on the south coast of England is twenty-four feet, at Hastings; the least being five feet, at Christchurch.

At all places westward of St. Alban's Head it is high water full and change, between 5^h and 6^h; and at all places eastward of the Head, between 11^h and 12^h.

The following Notes, taken from the Admiralty Tide Tables,* will be found useful to the Sailor when navigating the seas to which they refer.

Rio de la Plata.—After heavy gales from S.E. to S.W., the water in the Rio de la Plata may rise eight feet above the soundings shown in the Admiralty Chart; and continued winds from N.N.E. to N.N.W. may cause the water to fall to four feet less than the soundings.

Gulf of Mexico.—The tides of ports in the Gulf of Mexico, westward of Cape St. George on the N.E. shore of the Gulf, are usually single day tides, the rise and fall increasing or decreasing with the moon's declination. The rise and fall being so small, the times and heights are both much influenced by the winds. Between Cape St. George and Cape Florida there are two tides during the twenty-four hours, subject to a large diurnal inequality.

North Indian Ocean.—The tides of Aden and the Indian Ports are subject to a large diurnal inequality, which may either accelerate or retard the times of high water, sometimes to the amount of an hour and a half, or two hours, and increase or diminish the rise by a foot or more. In the river Hooghly the night tides are highest from November to to February; the day tides highest from March to October.†

The low water at Singapore is affected by a large diurnal inequality, amounting at times to six feet.

China Seas.—The tides on the coast of China are affected by a large diurnal inequality.

* The sailor's attention is here earnestly called to these useful Tables, now computed by Staff-Commander H. R. Harris, R.N., wherein will be found full information on the set of the Tidal Streams along the coast of Great Britain and Ireland, and also of the Channel Islands.

† See Tide Tables for the Indian Ports, by Captain A. W. Baird, R.E., and Mr. E. Roberts, *F.R.A.S.*, published yearly by the authority of the Secretary of State for India.

On the coast of Tongking there is generally only one high water in the twenty-four hours; occurring during summer in the p.m.; during winter in the a.m.

At Sarawak River the highest tides occur at the change of the monsoons, viz. May and November. In the N.E. Monsoon the higher tides occur at the new moon, and those of the day are higher and more regular than those of the night; while during the S.W. Monsoon the contrary takes place, and the higher tides are then at full moon.

At Whampoa Docks, near Canton, in March, the day and night tides rise to the same level. From April to October, the day tides are the higher, and from November to February the lower. In May and June the level of Spring tides is four feet, and the Neaps two feet higher than in March.

At Hongkong the range of tide is also affected by the winds, which may increase or diminish the range by one foot or more. From October to March, the night tides rise the highest; from April to September, the day tides are the highest. The highest night tides (which occur between October and January) rise about one foot higher than the highest day tides (which occur from May to September).

From tidal observations made at Wusung, the night tides between April and September were from three to one and a half feet higher than the day tides, while between October and February the day tides were from one foot to two and a half feet higher than the night tides. The spring tides between April and July rose four feet higher than those between October and December. At the Langshan Crossing, in the Yangtse-kiang, the tide rises for three hours only, and falls for nine hours. Above Nanking the waters during summer rise from twenty-four to fifty feet above the winter, or lowest level of the river.

At the Philippine Islands the phases of the moon have but slight influence on the time of high water or on the tidal range. The highest tides follow the moon's greatest north or south declination; the lowest tides follow the moon's least declination; at the moon's greatest north or south declination there is only one flood and one ebb in the twenty-four hours, at the moon's least declination there is one flood and one ebb in twelve hours. The greatest range of tide occurs generally in June and December, and is about six feet; the smallest range of tide is about three and a half feet, generally in March and September. The mean tide level varies during the year about seven inches; it is lowest in February and highest in August.

Australia.—The Australian tides are affected by diurnal inequality. On the east coast, from July to September, the night tides are from two to

four feet higher than the day tides; but after November the day tides are the same amount higher than the night tides.

At Sydney, between April and October, the night tides are higher than the day tides, and the reverse for the rest of the year.

At Port Adelaide, South Australia, between September and February, the day tides were found to rise higher than the night tides. Between March and August the reverse is said to be the case. About the neaps the tides are very irregular. At Port Augusta, when the wind veers round to W. and S., and blows strong, the rise has been as much as sixteen feet.

At King George Sound there is a large diurnal inequality of the tides, which sometimes reduces the two daily tides to one.

At Perth, in Western Australia, the tides are greatly affected by the winds. During N.W. gales the water remains about three feet above the ordinary level; this occurs all along the coast, and round Cape Leeuwin.

California and Oregon.—The tides on these coasts are of so complicated a character that the following general explanation is considered necessary:—There are generally in each twenty-four hours, or rather in each lunar day of $24^h\ 54^m$, two high and two low waters, which are unequal in height and in time in proportion to the moon's declination, differing most from each other when the moon's declination is greatest, and least when the moon is on the equator. The high and low waters generally follow each other thus: starting from the lowest low water, the tide rises to the lower of the two high waters (sometimes improperly called "half-tide"), then falls slightly to a low water (which is sometimes merely indicated by a long stand): then rises to the highest high water, whence it falls again to the lowest low water.

The tides at Sitka, on the west coast of North America, and also of Petropaulski, on the coast of Kamtchatka, are affected by diurnal inequality.

Instructions for the Use of the Tide Pole.

In all localities where operations for Sounding are carried on, a sheltered corner should, if possible, be found. in which the Tide Pole may be erected. A broken oar is driven into the sand, and supported by guys of spun yarn, or secured by stones or shot among the rocks (the place chosen being in about two feet of water), at low water, protected as much as possible, and yet with the sea having free access to it. To this oar a painted batten is lashed, conspicuously marked, the alternate feet being painted black and white, the figures six inches long, painted black on white ground and *vice versâ*; such *a batten* can be read from some distance with a telescope. The time is noted

for the rise and fall of every three inches, or the state of the pole marked every fifteen minutes, great care being taken to determine as near as possible the times of high and low water, by taking a mean of the times at which the water was at equal heights before or after high or low water. The time of high water is thus found by adding the times of the equal heights of the water together, and dividing by two. The state of the wind and barometer should be always noted.

If in port at the time of the full and change of the moon, it is advisable to especially observe the high and low water on that day, remembering also that the greatest rise and fall occurs from the third to the fifth tide after the full or change.

The times and heights of high and low water should, if possible, be observed successively both by day and *night;* and the watch or clock by which the times are taken should always show *mean time at the place.* The foregoing notes (page 210) taken from the Admiralty Tide Tables, showing how the tides in most parts of the world are affected by Diurnal Inequality, will prove the necessity of observing the *night* tides as well as the day tides; the *night* tides having been found to rise higher than the day tides at certain seasons of the year, while at the opposite seasons the reverse has been the case. The times of high and low water have also been found to have been affected in a similar manner. Tidal observations therefore cannot be considered as complete, unless the *night* as well as the day tides are carefully observed.

The greater the number of results thus obtained the more accurate will be the value deduced from them; if, however, circumstances will not admit of a continuous series of tidal observations being made, the day and night high and low waters that take place on those days when the moon's transit occurs between 11^h and 2^h, and 6^h and 8^h, should be preferred, as from the former (11^h and 2^h) the Tide Hour or Establishment and the Mean Spring Range are obtained, and from the latter (6^h and 8^h) the Mean Neap range is known.*

If there should be no available spot for the erection of the tide pole, or if the tide pole is not near enough to be noted from the ship (which may often be done by means of a telescope), supposing the ship to be moored, and the nature of the bottom at the anchorage level, a good idea of the daily rise and fall may be obtained by noting the depth alongside, by the method above described, with a well-stretched lead-line carefully marked for the purpose in feet and inches.

* See *Directions for Reducing Tidal Observations*, by the late Staff-Commander John Burdwood, R.N., published by the Hydrographic Office of the Admiralty.

From one or other of these methods a daily tide table may be made, showing, for every hour of the day, the number of feet to be subtracted from the soundings taken to reduce them to low water Springs.

The soundings should be reduced very shortly after the return to the ship by the officer who obtained them, and not entered even on the rough plan before they have been so reduced.

If the ship's stay is not long enough to get the times of high water at the full and change, that fact should be especially noted on the chart, and the rise and fall termed *approximate;* in this case, a comparison of the times and heights obtained, with those of some of the ports given in the Admiralty Tide Tables, that at the same age of the moon have a similar rise and fall, will enable an observer to form a tolerably correct idea of the necessary amount of reduction.

To determine the rise and fall of the tide, and to reduce the soundings accurately, require very considerable tact, judgment, experience, and patience; and these must not be given grudgingly, as the knowledge of the rise and fall of a foot is often of invaluable service to a sailor in difficulties.

For general purposes the following Table, for Reducing Soundings to the Mean Low Water of ordinary Spring Tides, will be found sufficiently correct.

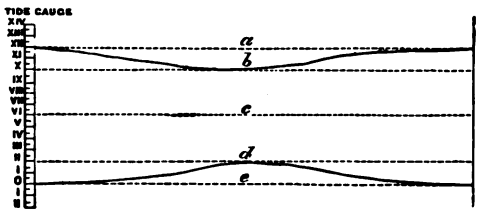
At Spring Tides.

At the	1st	hour,	before	and	after	high	water, deduct	$\frac{11}{12}$
"	2nd	"	"	"	"	"	$\frac{3}{4}$	Of the rise at Springs.
"	3rd	"	"	"	"	"	$\frac{1}{2}$	
"	4th	"	"	"	"	"	$\frac{1}{4}$	
"	5th	"	"	"	"	"	$\frac{1}{12}$	
"	6th	"	"	"	"	"	0	

At Neaps.

At the	1st	hour,	before	and	after	high	water, deduct	$\frac{1}{3}$
"	2nd	"	"	"	"	"	$\frac{3}{4}$	Of the rise at Springs.
"	3rd	"	"	"	"	"	$\frac{1}{2}$	
"	4th	"	"	"	"	"	$\frac{1}{4}$	
"	5th	"	"	"	"	"	$\frac{1}{8}$	
"	6th	"	"	"	"	"	$\frac{1}{8}$	

Diagram to explain the terms Spring Rise, Neap Rise, and Neap Range, as made use of in the Admiralty Charts and Sailing Directions.



a = Mean Level of High Water Ordinary Springs.

b = " " " Neaps.

c = Half Tide or Mean Level of the sea both at Springs and Neaps.

d = Mean Level of Low Water Ordinary Neaps.

e = " " " Springs.

Example.

Spring Rise (or Mean Spring Range) = e to a = 12 ft.

Neap Rise . . . . = e to b = 10 ft.

Neap Range . . . . = d to b = 8 ft.

Trinity High Water Mark, as established by Act of Parliament in 1800, is cut upon a large stone on the lower outer wing wall of the Hermitage entrance of the London Docks. Trinity high water mark is 12·53 feet above the Datum used by the Ordnance Survey, *i.e.* Mean Level of the sea at Liverpool: therefore by obtaining from the Ordnance map the level of any Bench mark and applying 12·53 feet to it, the level of the Trinity high water mark is found. The Trinity high water mark will be found cut upon the Tower Wharf, and also upon the front of the Fishmongers' Hall Wharf, next above London Bridge.

TIME.

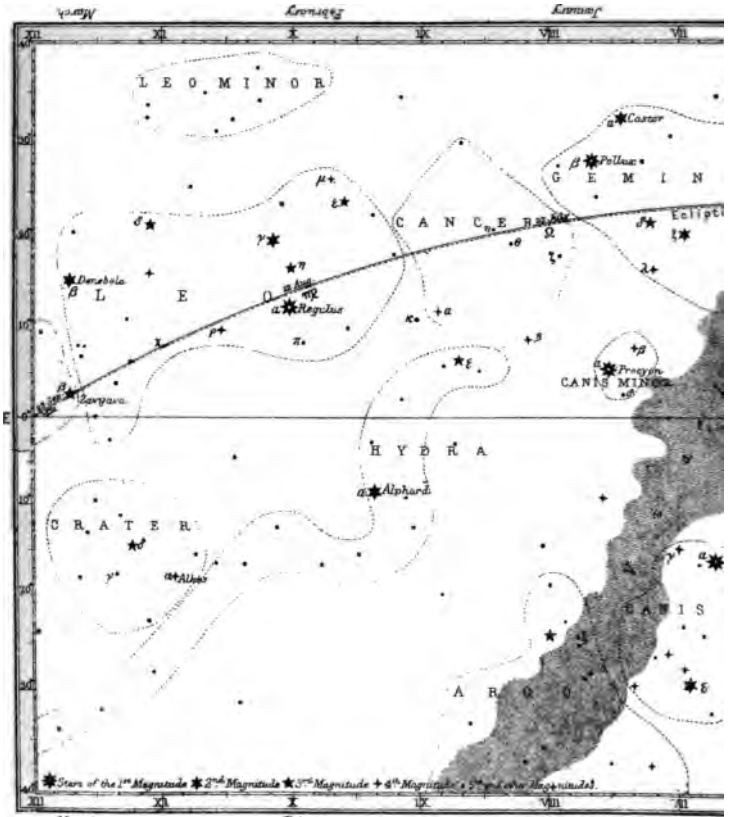
Before treating upon chronometers, it has been thought advisable to introduce a few simple remarks upon the standard units of Time. These explanations are essentially elementary, and should be treated as such; *i.e.* read only by those who may not clearly understand this, to the sailor, all-important topic, viz. the relation that exists between Apparent Time, Mean Time, and Sidereal Time.

Apparent Time is time shown by the sun-dial. The Apparent Solar Day is the interval of time that elapses between two successive transits of the sun over the meridian of the same place; these intervals are not the same at all times of the year; about the 21st of December, for example, they are half a minute longer than their average duration, and about the 21st of September nearly as much shorter; while on the 11th of February, the 14th of May, the 26th of July, and the 2nd of November, they are very nearly equal to it. Thus a distinction is pressed on our notice between the *actual solar day*, which is never two days in succession alike, and the *mean solar day* of twenty-four hours, which is the average of all the *actual* solar days throughout the year.

Mean Time is time shown by a good clock or chronometer. Mean time unites the two advantages of being regulated by the sun, and of being perfectly uniform. The Mean Solar Day of twenty-four hours is an average taken of all the days in the year; that is, such an interval of time as would elapse between two successive transits of the sun over the meridian of the same place if he moved uniformly in the celestial Equator. This Mean Solar Day is used in the general reckoning of time.

The Equation of Time.—The sun being generally either behind or in advance of the position which he would have occupied if he had moved uniformly, Mean Time is generally either fast or slow, on Apparent Time. The correction for this irregularity, that is, the difference between the sun-dial and the clock, or between apparent noon and mean noon, is called the Equation of Time. This difference between the sun-dial and the clock amounts to $14^m\ 29^s$ on about the 11th of February, to $16^m\ 19^s$ on about the 2nd of November, and is nothing four times a year.

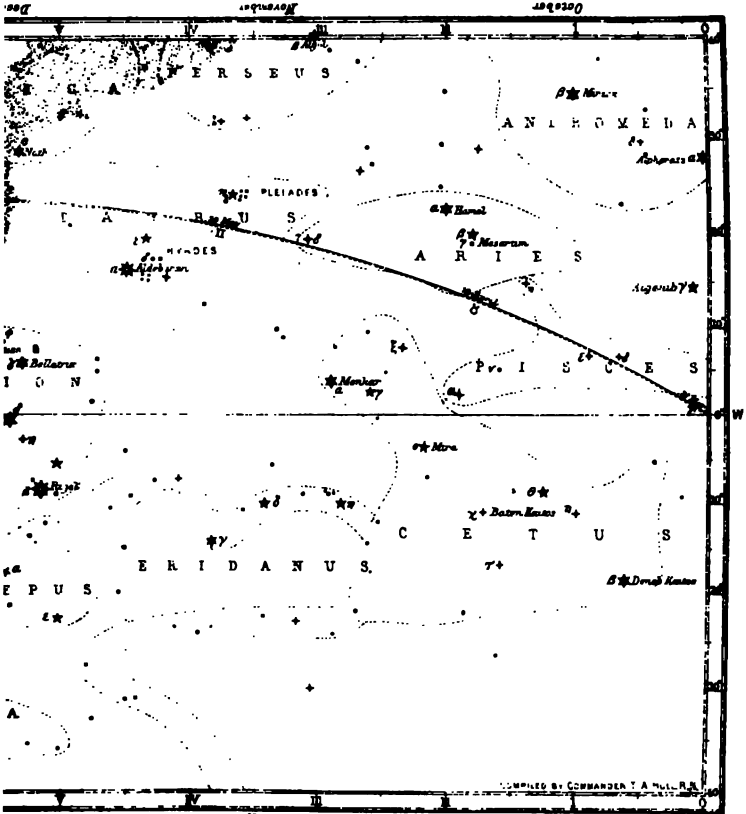
NORTHERN SIGNS OF THE ZODIAC AND



The months marked at the foot of the map are to show the aspect of the Equatorial Heavens at the opposite direction to the elevated pole, the difference

GRIFFIN & Co., PORTSMOUTH.

S BETWEEN DECLINATIONS 40° N AND 40° S.



...ber
...g the stars on the map immediately over the name of the month, and then looking at the sky in
...r be recognised. In Southern latitudes reverse the map

Clock *fast* of sun-dial, or mean noon comes before apparent noon, from about the

24th of Dec. to the 15th of April;
and from the
14th of June to the 31st of August.

To find Mean Time between the above dates, the Equation of Time must be *added* to Apparent Time, or time by the sun.

Clock *slow* of the sun-dial, or mean noon comes after apparent noon, from about the

16th of April to the 13th of June;
and from the
1st of Sept., to the 23rd of Dec.

To find Mean Time between the above dates, the Equation of Time must be *subtracted* from Apparent Time, or time by the sun.

N.B.—For general convenience, the time changing continually during a passage, Apparent Time is kept on board ship; this fact must be thought of by the sailor if looking out for the time of the meridian passage of stars to determine his latitude, which is always given in Mean Time.

Sidereal Time is time by the stars; a Sidereal Day being the interval of time that elapses between two successive transits of the same *fixed* star over the meridian of the same place. This day never varies, is less than the Solar Day, being $23^h\ 56^m\ 4{\cdot}09^s$, and is the period in which the earth makes one revolution on her axis.

Lunar Day.—The average duration of a Lunar Day, or the interval that elapses between two successive transits of the moon over the meridian of the same place, is $24^h\ 54^m$.

Lunation.—The interval between new moon and new moon is $29^d\ 12^h\ 44^m\ 2{\cdot}9^s$, while the average period of the moon's revolution round the earth is $27^d\ 7^h\ 43^m\ 11{\cdot}5^s$.

The Year.—The earth completes her revolution round the sun in $365^d\ 6^h\ 9^m\ 9{\cdot}6^s$ Mean Solar Time, or in $366^d\ 6^h\ 9^m\ 9{\cdot}6^s$ reckoned in Sidereal Time. This is called the Sidereal Year; but the year in which mankind in general are most interested is the Tropical Year of $365^d\ 5^h\ 48^m\ 49{\cdot}7^s$. This year, on which the return of the seasons depends, is the interval between two successive arrivals of the sun at the vernal equinox, or first point of Aries; and differs from the Sidereal Year by reason of the motion of the equinoctial points, known as the Precession of the Equinoxes. The Tropical Year is a compound phenomenon, depending chiefly and directly on the annual revolution of the earth round the sun, but subordinately and indirectly on its rotation round its own axis.

The Gregorian Calendar, now generally used among civilized nations, depends upon this Tropical Year, and may be thus briefly described:

Every year whose number is not divisible by 4 without a remainder consists of 365 days; every year which *is* divisible by 4 but is *not* divisible by 100, of 366 days; every year divisible by 100, but *not* by 400, consists again of 365; and every year divisible by 400 consists of 366 days. For example:

1873, not being divisible by 4, consists of 365 days.

1876, being divisible by 4, but not by 100, consists of 366 days.

1800 and 1900 being divisible by 100, but not divisible by 400, consist of 365 days each. 2000, being divisible by 400, consists of 366 days.

The error of the Gregorian Calendar amounts to only 0·944 days in 4000 years.

Conversion of Time and Arc.

To turn Time into Degrees, Minutes, and Seconds of Arc.

RULE.—Turn the hours into minutes and divide by 4; the result will be degrees, minutes, and tenths of a minute of arc.

Example—$7^h\ 40^m\ 53{\cdot}73^s = 460^m\ 53{\cdot}73^s \div 4 = 115°\ 13{\cdot}43' = 115°\ 13{\cdot}26''$.

To turn Arc into Hours, Minutes, and Seconds of Time.

RULE.—Multiply the arc by four; this converts the degrees into minutes, the minutes into seconds, and the seconds into thirds of time.

Example—$115°\ 13'\ 26'' \times 4 = 460\ \ 53^s\ 44^t = 7^h\ 40^m\ 53{\cdot}73^s$.

CHRONOMETERS.

THE important services rendered by chronometers in the ordinary course of navigation are well understood and fully appreciated by all intelligent seamen. A few notes therefore on the general treatment of these valuable instruments, extracted principally from that most useful work by Admiral Sir Charles Shadwell, K.C.B., F.R.S., on the management of chronometers, are here inserted.*

* For further information on this important subject, see Admiral Shadwell's most admirable work, *Notes on the Management of Chronometers and Measurement of Meridian Distances.* —*J. Potter*, 31, Poultry, E.C.

When chronometers are received on board ship, it is of importance that they should be at once stowed away in the place prepared for their reception, and when once suitably located, they should on no account be subjected to removal or displacement.

The chronometers should be placed low down in the ship (both because there is less motion, and because the temperature is more equable), amidships, as far from the extremities and as near the centre of gravity as convenient; not near the chain cables, or other large masses of iron, so as to insure freedom from the disturbance of magnetic influence; and not in drawers, where the tremor caused by opening and shutting them acts injuriously on their balances.

The best mode of stowing them seems to be as follows:—A box, divided into as many partitions as there are chronometers to be stowed away, should be securely attached by screws to a solid block of wood, about thirty inches in height, and firmly bolted to the beams of the deck below. Each partition should, in depth, be about equal to that of the largest box of the chronometers to be stowed away, and in length and breadth about two inches longer than the sides of the box it is intended to secure. Great care should be taken that the block and partitioned box, thus prepared, should be entirely detached from all contact with contiguous stanchions or bulkheads; the block and box, moreover, should be surrounded with a strong external casing, the sides and lid of which should on no account be permitted to touch it, a clear space of at least two inches being left all round. Previous to placing the boxes containing the chronometers within the partitions appropriated for them, it will generally be found convenient to unscrew and altogether detach their lids; because, if this be not done, when open they occupy much more room, and will require the partitioned spaces for their reception to be made inconveniently large.

Each chronometer in its box thus prepared, and moving freely in gimbals, is then to be placed in the space allotted to it on a bed of dry sawdust, horse-hair, or cotton, about three inches thick—the spaces around the sides of each box being stuffed, with the same material, to within half an inch of the top of the box. Of the three substances named above, dry sawdust is preferred.

The marks on the dial-plate of the chronometers should all occupy the same relative positions: that is, the line joining the XII. and VI. hour marks should all be parallel to one another, both for the sake of the convenience of comparison, and in order that, retaining the same invariable position with reference to the fore-and-aft line of the ship, they may be similarly affected by the local magnetic attraction of the ship's iron, and that

in cases where the balances of the chronometers have accidentally acquired any degree of polarity, their mutual influences on each other may be reciprocal.

Generally speaking, it is not the custom to receive the chronometers on board the ship until a few days before leaving the harbour, the time of the officers, who will subsequently be charged with the duty of superintending their performances, being at that period much occupied with other important matters, connected with the equipment of the ship; but, as from the influences of the new circumstances under which the chronometers are placed, the effects of motion in removing them, change of temperature, and possible action of magnetic causes, their rates, after a while, may differ from their previous rates on shore, it is very advisable, when practicable, that they should be received on board at an earlier period, so that they may become *naturalized* in their new position, and may have settled down to a stability of rate under their new conditions before the ship is called on to proceed to sea.

The chronometers having been received on board, and stowed away in the manner above described, in the place appropriated for their reception, it is of importance at once to commence and adopt an uniform and systematic manner of winding them up, and comparing them daily with one another. Methodical arrangements in these particulars favour the stability of rate of the chronometers, assist in the detection of irregularities, and diminish the probabilities of their being accidentally allowed to run down; while, in the reduction of chronometric observations for the determination of meridian distances, systematic plans of comparison are indispensable to accuracy of computation.

As a rule, 8^h a.m. is a time conveniently adapted to these duties, and consistent with the arrangements of sea service.

The chronometers should be wound *first* and compared *afterwards*. In winding them up they should be habitually attended to, in the same order, from day to day, one by one, as they lie in their places; so that the mechanical habits of regularity in this particular may be a safeguard against the caprice of memory or accidental distraction, from any disturbing cause. From want of system, in this particular, we have known instances where the attention of the officer, engaged in this duty, being accidentally distracted during its performance, the chronometers have been compared, but some or all of them not wound up, that operation being forgotten, and the omission not detected till the chronometer ran down. In winding up chronometers, the turns of the key should always be counted, and the last turn made gently *and carefully, until it is felt to butt.*

In winding up box-chronometers, the chronometer should be inverted carefully in its gimbals, held firmly in the left hand, and the key pressed home with the right; after the operation is performed, and the key withdrawn, care should be taken that the keyhole is again covered with the slider to secure it from dust or damp, and then the chronometer should be *gently eased down* into its natural position without violence or jerk.

In winding up pocket-chronometers, the watch should be held firmly in the left hand, with the wrist pressed gently against the breast, the key should be turned equably and steadily with the right, care being taken to avoid giving the watch any circular motion upon the key. The common but vicious practice of turning the left as well as the right hand is injurious, for two reasons: first, because the circular motion affects the regularity of the balance; and secondly, because the compound motion of the two hands doubles the velocity of winding, and increases the chances of straining or snapping the spring from the jerk at the conclusion of the operation.

The chronometers should be wound *daily*, whether constructed to go for one or two days; eight-day chronometers, once a week,—say, on Sunday, a day easily remembered. If the number of chronometers is large, the precaution should be taken of examining them after winding, either by looking at the winding index on the dial plate, or if not furnished with that apparatus, by trying the key.

The chronometers having been all wound up, they should next be compared. To facilitate their systematic comparison, and to organize more easily the reduction of chronometric observations, it is customary to select one chronometer as a "*standard*," * to which all observations, for the determination of the time, are in the first instance referred; the indication of the other chronometers at the same moment being subsequently obtained by means of the comparisons.

The chronometer selected to perform the duty of the "*standard*" should be one of first-rate character, and by a maker of established repute; it will be convenient that it should have a clear and distinct beat to half-seconds; also, that its dial plate be well marked; and it is advisable, although not indispensable, that its rate should be small. Stability of rate, however, is at all times much more important than the smallness of its amount. It is very desirable, when practicable, that the comparisons of the chronometers

* For the facility of comparison with the other chronometers it will be found convenient to arrange the chronometers in their box in such a manner that the standard shall occupy a central position among them.

with the "*standard*," should all be made by one person. The effects of personal equation are thereby much simplified, and the chances of small contingent errors materially diminished.

The practical seaman will never be content to use the rates he may receive with the chronometers on their leaving the shore, when these lifelike inventions, to use the admiral's excellent phrase, are "not naturalized in their new positions." Pressure of business may, possibly, force the sailor to use, for a time, the maker's or observatory rate, but he will take the earliest opportunity of getting his own rate, and watch, with a jealous tenderness, the performance of these delicate instruments, on whose accuracy the honour and safety of his ship are alike dependent.

As a matter of practice, it seems advisable, when circumstances permit, that the rate of a chronometer should not depend on observations made at an interval of *less* than *five* or *more* than *ten* days. Seven days will be found a convenient average interval, and in the case of eight-day chronometers, moreover, it is nearly the period affected by the whole length of the chain. With the above limitations, it may be laid down as a maxim, that chronometers cannot be rated too often when time and opportunity permit. The error and rates of the chronometers should, if possible, be obtained by observing equal altitudes of the sun; failing this, by forenoon or afternoon sights, taking care that if the observations on the first day are made in the forenoon, that those on the second day should, if circumstances permit, be also made in the forenoon, and *vice versâ*.

The Hack-watch* used in rating chronometers should, on the days of observation, be carried in a box, and not kept in the pocket, care being taken to compare it with the standard chronometer on leaving and returning to the ship, both in the forenoon and afternoon.

Practice will soon make the earnest navigator an expert observer, and in addition to the safe conduct of his ship, he will often be able, by measuring Meridian Distances, to be of great assistance to his fellow seamen, by furnishing them with the longitudes of places hitherto unknown. The table on page 224 will show by what a simple method chronometers may be rated, and a meridian distance measured.

N.B.—A competent and practical knowledge of what can be done with anchor and compass; log-line and lead-line; sextant and chronometer; chart, scale, and dividers; is the secret of success in a profession whose members live by utilizing the forces of wind and water.

* The Hack-watch is a pocket chronometer or good watch, used to observe with, and to *avoid moving a box* chronometer.

Defective Chronometers being very liable to injury on their passage from abroad or when travelling on shore, the following precautions in sending them are to be adopted:—

1. Wedge the balance with cork, so as to prevent any movement in it whatever.

[*Instructions.—Take the brass case containing the chronometer out of its gimbals, unscrew the glass face, and remove the chronometer from its brass case. Secure the balance with two thin wedges of cork between the balance and the plate, so as to prevent any movement of the balance. Replace the chronometer in the case, and the case in the gimbals.*]

2. Turn the screw-catch into the gimbal ring and the metal box of the chronometer, and screw it there fast, so as to prevent either of them from moving. If there appears to be the slightest probability that the gimballing can come loose, or the gimbal-block can fail, secure them by tying the screw-catch fast, putting a wood screw into the block, or adopting any other suitable measures.

3. Fill the whole space between the metal box and its wooden case with any stuffing, such as dry oakum free from dust, or dry paper shavings free from dust (wood shavings are sometimes objectionable as bringing turpentine and dirt), or any other dry, clean, and soft material, so that, even if the chronometer should break loose from its gimbals, it cannot change its place in the box.

4. Having closed the wooden chronometer box, it is to be placed in a wicker basket or hamper, or in a box of partially yielding character, and is to be packed in it with abundance of soft stuffing. If there is no wicker basket at hand, or nothing except a wooden box, this box must be surrounded with a large quantity of stuffing and inclosed in canvas, so that it can never receive a jarring blow. It is of the greatest importance that the outside of the packing case be soft and yielding.

4. Two or more chronometers (secured from injury in their boxes by the foregoing measures 1 to 3) may be packed in a yielding case or basket, but all contact between them must be prevented by precautions similar to the above with straw or some stuffing material.

5. Address the package to the Astronomer Royal or chronometer maker, in characters distinctly legible, adding the words "Chronometers, with care," the date, and name of the ship sent from, and when forwarded by land, that of the rail by which it goes to Greenwich; a mail or passenger train being adopted, but never a luggage train.

Meridian Distance between Beirut and Sidon.

Losing rates are marked —; gaining rates marked +.

Numbers of Chronometers.	Dent, 1793. Standard.	McCabe, 187.	Frodsham, 2714.
	h. m. s.	h. m. s.	h. m. s.
Standard fast on Beirut mean time, June 17th, 1861	7 15 0·79	7 15 0·79	7 15 0·79
Comparisons (standard being fast on Chronometers)*	..	9 11 15·00	9 35 15·00
Chronometers fast on Beirut mean time, June 17th, 1861	7 15 0·79	10 3 45·79	9 39 45·79
Ditto Ditto, June 11th, 1861 ..	7 15 11·68	10 3 43·68	9 39 41·68
Rate in six days	10·89	2·11	4·11
Daily rate	.. — 1·81	+ 0·35	+ 0·68
Ditto obtained at Sidon in June	.. — 1·91	+ 0·18	+ 0·59
Beirut-Sidon rate	.. — 1·86	+ 0·26	+ 0·63
Chronometers fast on Beirut mean time, June 17th, 1861	7 15 0·79	10 3 45·79	9 39 45·79
Rate in three days by Beirut-Sidon rate	.. — 5·58	+ 0·78	+ 1·89
Chronometers fast on Beirut mean time, June 20th	7 14 55·21	10 3 46·57	9 39 47·68
Chronometers fast on Sidon mean time, June 20th	7 15 25·91	10 4 16·91	9 40 18·41
Meridian distance, Beirut and Sidon ..	30·70	30·34	30·73

s.		
30·70	Long. of Beirut ..	35° 29′ 04″ E.
30·34		— 7 39
30·73	Long. of Sidon ..	35 21 25 E.
91·77		
Mean 30·59 = 7′ 39″		

* It will be found convenient, in working out the rates of chronometers and meridian *distances, always to consider* the chronometers as *fast*.

Sextant.—A practical acquaintance with the sextant is necessary to enable the navigator thus to rate and utilize his chronometers; he should therefore lose no opportunity of making himself thoroughly conversant with this useful instrument, understanding all its peculiarities, causes of error, etc.

He must remember that even in the best sextants errors may exist through the natural eccentricity of these instruments, or the difficulty of fixing the axis of the index glass concentric with the graduated arc; if equal altitudes cannot be obtained, a mean of a.m. and p.m. sights should be taken; if neither equal altitudes nor sets a.m. and p.m. can be obtained for rating the chronometers, care should be taken to work the a.m. sights of the first day with the a.m. sights of the second day, or p.m. with p.m., making sets of those observations that were taken at about the same altitude; and if possible never to work a.m. sights with p.m., or p.m. with a.m., to obtain a rate.

In making these observations, with the artificial horizon, the eye-piece of the inverting tube should, if possible, be used instead of the shades of the sextant; if shades are used, endeavour always to use the same. The meridian altitude of the sun, when taken in the artificial horizon, should be observed with the eye-piece, as the latitude obtained from it can then be meaned more satisfactorily with those determined by the stars.

In observing stars north and south of the zenith for latitude, similar care should be taken to pair those of about the same altitude; therefore, in the northern hemisphere the best south stars to pair with Polaris are those whose meridian altitudes are about the same as the latitude of the place. To obtain latitudes from sun and stars on shore, circum-meridional altitudes are generally used, taken from twenty minutes before, to fifteen minutes after, the meridian passage.*

Similarly, in taking Lunars, stars lying at about equal distances, east and west of the moon, should be chosen. The practice of lunar observations should by no means be neglected by young officers. Chronometers may fail; in giving an officer charge of a prize, his captain may not be able to spare him a chronometer; but the Great Greenwich Clock, formed by the moon and stars, is at his disposal, in clear weather, for about twenty-five days in each month.

Artificial Horizon.—In using the artificial horizon care must be taken in pouring out the quicksilver. Sir Edward Belcher gives the following useful hints:—"Place the finger over the orifice of the bottle, and give it a

* Sailors anxious to acquire a practical knowledge of the names and positions of all the stars of the first and second magnitudes, are referred to Jean's *Handbook of the Stars*, and to the star maps in this work.

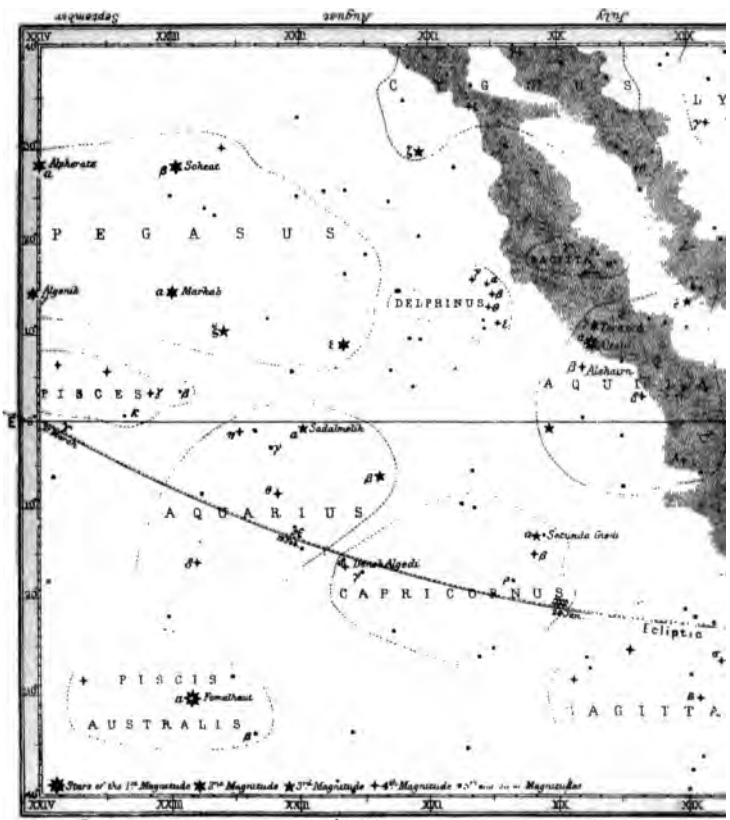
shake in an inverted position, holding it over the trough previously cleaned. Ease the finger, and allow the mercury to flow gently, keeping the bottle inverted, and taking care to stop the opening of the bottle before the last portion with the dross flows. This will produce a clear brilliant surface."

In pointing the artificial horizon towards the sun, see that the shadow is thrown directly behind it, and not on either side. The spot chosen for making these observations should be sheltered from the wind, and, to be free from vibration, removed from traffic. The roof of the artificial horizon should be so placed that the same glass is always towards the observer. A mark may be made on the glass or on the framework to insure this precaution being carried out. If observations are taken on one side of the meridian only, it may be advisable to reverse the roof, obtaining sets with both glasses, and taking a mean to work with.

Observations at Night.—Obtaining latitudes at night with the artificial horizon requires some practice; see that it is placed in the true meridian before the observations are commenced. The approximate mean times of the meridian passages of the stars to be used should be calculated from the *Nautical Almanac*, the error on mean time of the watch in use should then be applied to them; these times of the meridian passsages *as shown by the watch in use* should be entered in the sight book as a guide to the observer, together with the approximate meridian altitudes. The stars selected should, if possible, be of convenient altitudes, neither too high nor too low; care should be taken to find the reflected image of the star in the quicksilver some little time before it comes on the meridian. A handy sailor should be trained to hold the dark lanthorn, by which the observations must be first noted by the watch, and then read from the sextant in such a manner that, while the assistant who is taking time can see the watch, no light is thrown in the direction of the artificial horizon. On the time being secured, the light is taken to the observer with the sextant. Practice is required both in holding the lanthorn and in reading off the sextant. The roof of the artificial horizon may require wiping occasionally, on account of the dew.

Norie's Complete Epitome of Practical Navigation contains all necessary instruction for keeping a ship's reckoning at sea, with approved methods of ascertaining the latitude and longitude. This work, written in a clear, practical, and seaman-like style, and illustrated by several engravings, renders the study of Navigation an easy matter, and fully deserves the confidence that officers of the Mercantile Marine have for many years placed in it.

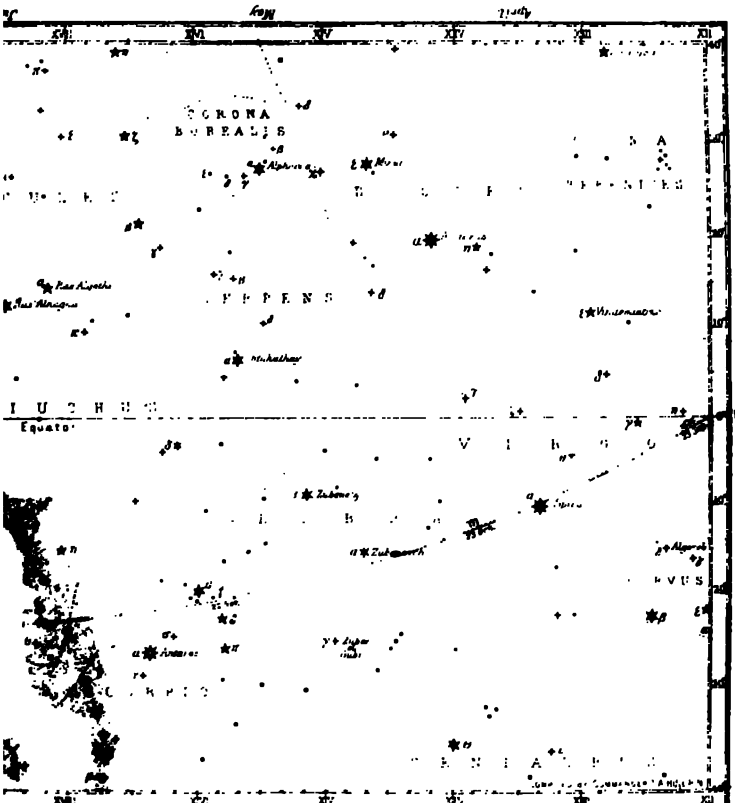
SOUTHERN SIGNS OF THE ZODIAC AND



The months marked at the foot of the map are to show the aspect of the Equatorial Heavens at
the opposite direction to the elevated pole, the differenc

GRIFFIN & Co., PORTSMOUTH.

IS BETWEEN DECLINATIONS 40° N. AND 40° S.



ig the stars on the map immediately over the name of the month and then looking at the sky in
be recognised. In Southern latitudes reverse the map

Raper's Practice of Navigation and Nautical Astronomy.*

It is here thought necessary to call the sailor's earnest attention to the above work, by the late Lieutenant Henry Raper, R.N. The friend of that first of Hydrographers, the late Sir Francis Beaufort, Lieutenant Raper had not only the advantage of the society and experience of Sir Francis and his captains, but also had the assistance of the late Mr. Michael Walker, then Assistant Hydrographer and Chief Draughtsman, and other gentlemen of the Department, "whose patience," writes Lieutenant Raper, "during many years I have sorely taxed in the inspection and re-examination of thousands of documents, and without whose active and disinterested assistance I must have left much in a very unsatisfactory state."

This book is essentially the work of a sailor, who wrote with a considerate knowledge of his brethren of the sea. Its painstaking author has supplied the sailor with a *vade mecum* that embraces all points necessary to safe navigation, and the following extract from the preface to the first edition will be its best recommendation :—

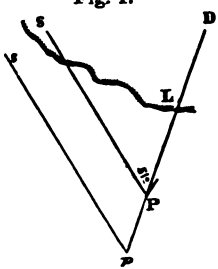
"The present work, which is devoted exclusively to the PRACTICE, contains all the rules and tables necessary in navigation, and for the determination of latitude and longitude by means of the *sextant*. The study of its contents demands no previous attainments beyond the knowledge of the elements of arithmetic. Every endeavour has been made to render the whole easy of reference, and to adapt it to the use of those who may desire to instruct themselves.

"Those who have been brought up to the sea, and who have experienced the distaste for long calculations which that kind of life inspires, will not hesitate to admit that the only means of inducing seamen generally to profit by the numerous occasions which offer themselves for finding *the place of the ship*, is extreme brevity of solution. It is not, however, merely as a concession to indolence that rules should be made as easy and simple as possible; the nature of a sea life demands that every exertion should be made to abridge computation, which has often to be conducted in circumstances of danger, anxiety, or fatigue. These considerations have been carefully kept in view in the rules, in the examples, and in the form and order of the tables."

* Published by J. D. Potter, 31, Poultry, E.C. Agent for the sale of the Admiralty Charts.

DETERMINING POSITIONS, etc.

Fig. 1.



WHEN in sight of land that has been properly surveyed a common method of fixing a ship or boat is by observing two objects on the chart that are in transit, *i.e.* situated in the same line as the ship or boat, and taking an angle between them and some well-known object to the right or left, taking care that the angle measured is not less than 25°. A line is then ruled through the objects in transit, any point is taken in it, and from this the angle observed is laid off in the direction of the third object; a line, ruled through that object, parallel to the line forming the angle will intersect the line ruled through the objects in transit on the position of the ship.

Thus in Fig. 1, two points, D and L, whose positions are known, are observed to be in transit from a station P, and an angle LPS of 51° is measured between them and a third known point S; through D and L a line DL*p* is drawn, and at any point *p* in that line, an angle D*ps*, equal to 51°, is laid off towards S, and a line *ps* drawn; then through S a line SP is drawn parallel to *sp*, cutting DL*p* in P, the position required.

A true or magnetic bearing may also be taken of either S or D, this bearing is then ruled upon the chart, and the position of the observer fixed, by projecting in a similar manner the angle measured between the objects.

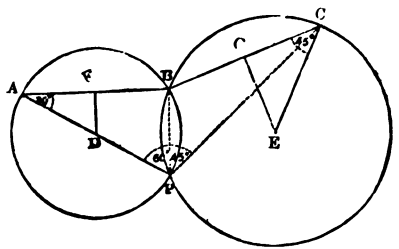
The position of the ship may also be fixed by projecting the angles measured from her between three objects on shore, whose bearings and distances from each other are known to the observer by means of a chart.

In the selection of three objects to fix a position by, the middle object should, if possible, be the nearest to the observer, or the three objects should be in or near the same straight line, or the observer's position should be within the triangle formed by the objects. If the objects and position of the observer lie in or near the circumference of the same circle, the position cannot be fixed without the assistance of a true or compass bearing of one of the objects.*

* Where a couple of angles are taken to fix a ship running along a coast, or in a harbour, a *compass bearing of one* of the objects used should always be observed at the same time.

Projecting by Circles. **Case 1.**—Let A, B, and C be three objects on a chart (see Fig. 2): it is required to fix the position of a ship P, by angles; the one measured between C and B being 45°, and that between B and A being 60°.

Fig. 2.



Join AB, BC, and bisect them in the points F and G, erecting the perpendiculars FD, GE on the same side of the objects as that on which the ship lies. Then at A make the angle FAD = 30°, the complement of the angle measured between B and A, and at C make the angle GCE = 45°, the complement of the angle measured between C and B, and draw lines AD, CE, cutting the perpendiculars FD, GE, in D and E. From D and E as centres describe the circles ABP and CBP, and the intersection of their circumferences at P will be the position of the ship. Where a couple of angles are taken to fix a ship running along a coast, or in a harbour, a compass bearing of one of the objects used should, if possible, always be observed at the same time.

Case 2.—Should the angle be greater than 90°, erect the perpendicular on the opposite side of the line joining the objects to that on which the ship lies, and making the angle FAD = (90° — the angle subtended), and proceed as before (see Fig. 3, where the angle measured between C and B is 70°, and that between B and A is 120°).

Fig. 3.

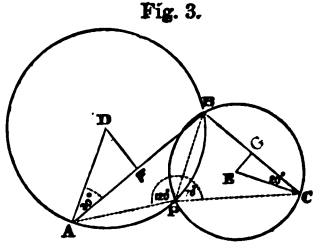
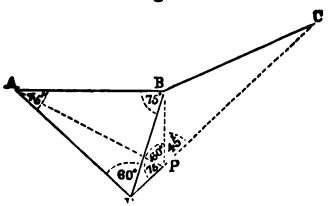
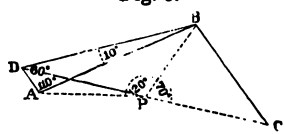


Fig. 4.



By the Straight Line Projection. Case 1.—At B (see Fig. 4), on the same side of the objects as that on which the ship lies, make the angle ABD = 75° or 180° − (60° + 45°) : at A make the angle BAD = 45°, or the angle subtended by the side BC: join CD, and on CD make the angle BPC = 45°: the point P will be the position required.

Fig. 5.



Case 2.—When the sum of the angles measured is more than 180° (see Fig. 5) at B, on the opposite side of AB to that on which the ship lies, make the angle ABD = 10°, or (120° + 70°) − 180° : at A make the angle BAD = 110°, or 180° − 70°, the angle subtended by BC ; join CD ; and on CD make the angle BPC = 70°; the point P will be the position required.

A vessel's position may also be determined by laying off the angles taken between three known objects on a piece of tracing paper with a protractor. Rule upon the tracing paper a straight line representing the line from the ship to the centre object, and from any convenient point on this line set off the angles observed to the right and left, and draw the lines on the tracing paper; lay the tracing paper on the chart, and move the tracing paper over the surface of the chart, until the three lines pass through the respective objects; that done, the point on the tracing paper from which the angles were laid off will be the position of the ship. If the Magnetic North from the compass bearing taken of one of the objects observed (corrected for deviation) be also drawn upon the tracing paper, it will much facilitate the finding of the ship's position.

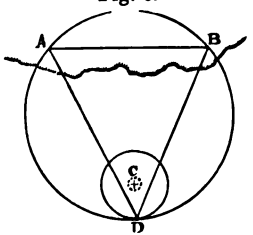
The Horizontal Danger Angle.*

This problem is based upon Euclid, Book III., Prop. 21, that angles in the same segment of a circle are equal to one another. The Danger

* Useful tables of *Vertical Danger Angles* of heights from 50 to 12,000 feet, to distances of from one cable to 86 miles, have been calculated by Lieut. S. T. S. Lecky, R.N.R. *Published by* George Philip and Son, London and Liverpool.

Angle should only be used with two well-defined points on a well-constructed chart.

Fig. 6.



Example.—Suppose C a well-known danger under water, A and B two well-defined points. It is required to pass clear of C at five cables' distance. Describe a circle round C, with a radius of five cables, and on the circumference to seaward of the danger, take a point D. Join AB, AD, DB, and describe a circle about the triangle, ADB. The angle ADB, in this case 50°, is the danger angle, which being set upon a sextant, will, so long as kept on, place the ship on the segment of the circle, ADB, and clear of the danger C. Should the angle increase, the vessel will be inside the circle, and *vice versâ*.

Remarks on taking Observations at Sea.

Terrestrial Refraction.—The apparent elevations of the summits of high land are subject to great variations depending upon particular states of the air.

The apparent place of the sea horizon differs also with different temperatures of the sea and air. When the sea is *warmer* than the air, the horizon appears below its mean place as that at which it is seen when the air and water are at the same temperature, and the dip taken from the tables is too small; when the sea is *colder* than the air, the horizon appears *above* its mean place, and then the tabular dip is too great. These facts being well known, where great accuracy is required the following precautions should be taken:—

When the altitude of a heavenly body is above 60°, the altitude may be observed with the sextant from the opposite point of the horizon, as well as from the horizon directly under it. Half the difference of the two readings is the apparent zenith distance of the centre. By this means the dip and its uncertainties, together with the index error, are removed. When both the altitude and its supplement are thus measured, and the altitude (the object not being on the meridian) is in a state of change, the time must be noted at each observation; and the resulting zenith distance will correspond to the mean of the times.

When fog obscures the horizon from the deck, a new horizon may often be obtained by descending the ship's side or from a boat.

When the sun's limbs are indistinct, altitudes of the centre may be obtained by bisecting the hazy disc upon the horizon.

Height of Waves.—The running of large waves causes the horizon to be in continual motion; while the rise and fall of the observer, both from the lifting of the ship by the waves and her rolling, cause the dip to be continually changing. For this reason a mean of three or five sights should always be taken in rough weather, or in a small vessel.

If the altitude be observed above the deck, as in the top for instance, the horizon will appear better defined, and the variations of the dip caused by the ship's motion will be less sensible; also the difference of the temperature of the sea and the air appears to affect the place of the sea horizon less as the observer is more elevated.

From numerous observations made upon the heights, distances, and velocities of waves, the heights are found to vary from 14 to 32 feet. Sir James Ross observed waves of 36 feet in height. The distance from crest to crest of such waves is from 150 to 340 feet, while their velocity appears to vary between 17 and 28 nautical miles per hour.

Remarks on Sumner's Method by Staff-Commander John Cumins Richards, R.N.

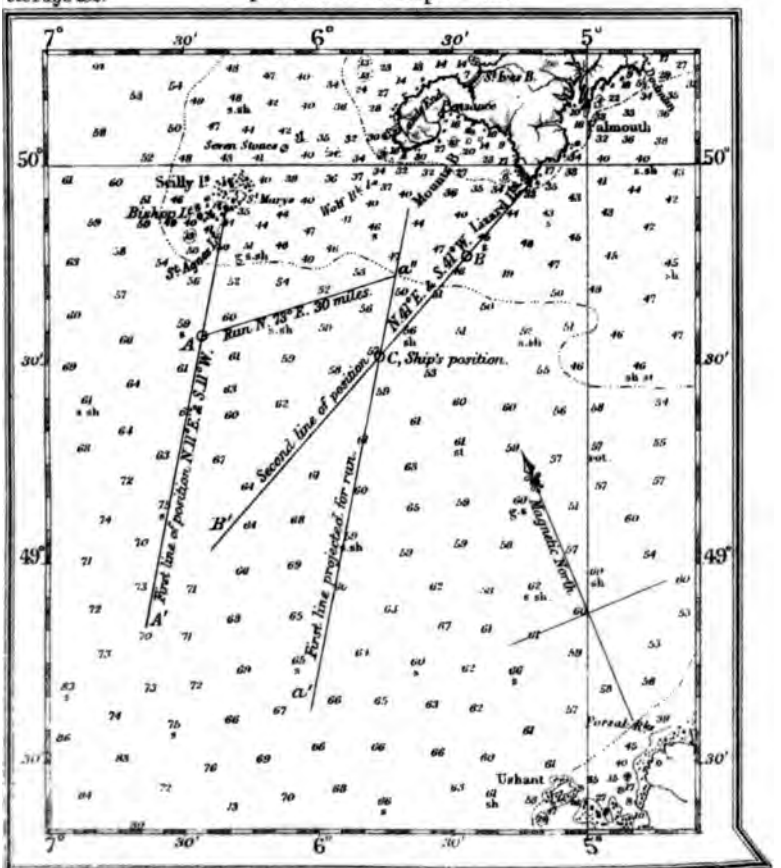
To the navigator the importance of Sumner's method can scarcely be overrated, and it is not too much to say that it is one of the most valuable methods for finding a ship's position at sea ever discovered; the computation required is merely a small extension of the everyday work in navigation.

Briefly stated, Sumner's method involves finding by means of an observed altitude of a heavenly body and two assumed latitudes, two longitudes by chronometer; the line on the chart, joining the two points so obtained, being called the *line of position*. A second observed altitude, separated from the first by a suitable difference of bearing, gives by similar treatment another line of position, the intersection of which with the first line of position projected for the run of the ship in the interval (that is, moved parallel to itself along the course and distance made good by the ship) determines the place of the ship at the second observation. The line of position can, however, be obtained from *one* assumed latitude if the true bearing of the sun or

DIAGRAM

To illustrate Staff Commander J.C.Richards' Remarks on Summer's method for finding the position of a ship at sea.

See Page 232.



ALL BEARINGS ARE TRUE.

celestial object observed be known, for the direction of the line of position differs 90° from the direction or bearing of the object.

The tables of sun's true bearing or azimuth, by the late Staff-Commander Burdwood, for the parallels of 60° to 30°, and the tables by the late Captain Davis for the parallels of 30° to the Equator, supply the true bearing of any celestial object whose declination does not exceed 23°. By means of these useful tables the computation of a "Sumner" is shortened by one-half.*

Example.—See Diagram.

Apparent Time.	Sun's true Altitude.	Sun's Declination.	Assumed Latitude. (D. R. lat.)	Resulting Long. by Chrono-meter.	Sun's true Bearing from Azm. Tables.	Direction of line of position = Sun's Azm. ± 90°.
FIRST OBSERVATION.						
8h 8m a.m.	35° 30′	20° N.	49° 35′ N.	6° 26′ W.	N. 101° E.	N. 11° E. and S. 11° W.
			Point A.			Line AA′
SECOND OBSERVATION.						
10h 2m a.m.	52° 10′	20° N.	49° 47′ N.	5° 27′ W.	N. 131° E.	N. 41° E. and S. 41° W.
			Point B.			Line BB′.

Aa″, run of the ship in the interval between the first and second observations, N. 73° E. *true*, distance thirty miles.

A′A, Line of position at first observation. a′ a″, same line projected for run of ship, cutting BB′, the second line in C, which is ship's true position at second observation in lat. 49° 32′ N., long. 5° 46′ W.

The line of position at first observation, A′A in diagram, should be drawn as soon as the observations are taken and worked, and, as the ship is somewhere on this line, the bearing of any land or object it may pass through is

* These tables should be found in every ship. In iron vessels Burdwood's and Davis's Azimuth Tables may be said to be indispensable.

at once determined; a single observation yielding such a line of position may, therefore, become exceedingly valuable. Thus, in the diagram, the first line of position passes through St. Agnes, Scilly Islands, which consequently bears N. 11° E.; also the second line of position, BB', passes through the Lizard, which bears N. 41° E. When the coast trends parallel to the line of position, the distance of the ship from the shore is ascertained, although her absolute position is uncertain. Also a line of position and a cast of the lead—we are never tired of insisting on the use of the lead, and if a vessel is supplied with Sir W. Thomson's sounding machine there is no difficulty in obtaining the required *cast of the lead*—where the soundings are well laid down, will give the ship's position approximately. Thus, at the first observation, a cast of sixty-three fathoms would show the ship to be about fifteen miles to the southward of the point A on the diagram.

When the ship is steering a straight course, the line indicating the track can, from any point in A'A, also be drawn, and the distance laid off on the completion of the second observation. The convenience of allowing in this manner for the run of the ship in the interval is worthy of special attention, as one-half the computation is performed without waiting until the second observation is taken; this is an advantage a "Sumner" has over the ordinary double altitude problems.

The lines of position must not cut too acutely, or the unavoidable errors of observation will be considerably magnified. The difference of bearings should not be less than 25° nor greater than 155°.

The latitude assumed should be the latitude by dead reckoning, as being nearer the truth than any other; this is important when the altitude is high. In low latitudes, when one observation falls within the limits of the problem for finding the latitude by Reduction to the Meridian (see Raper's Navigation Table, 47), this method should be used in preference to finding a line of position by "Sumner."

An error in the chronometer places the line of position too far east or too far west, but does not alter its direction. An error in the altitude will move the line of position parallel to itself towards or from the celestial object.

Longitude from Equal Altitudes at Sea.

When the sun's meridian altitude is over 70°, the longitude of the ship may be determined at the same time as the latitude, with sufficient accuracy for the ordinary purposes of navigation, by observing the times at equal altitudes of the sun, about five or six minutes before and after noon. The sum of these times divided by two and corrected by the Equation of Time *applied as to Mean Time*, will give the time of mean noon at ship as shown by the watch. Applying to this time the error of the watch on Greenwich will give Greenwich time at the mean noon of the ship, which is the longitude in time.

Example.—On the 5th of April, 1876, in lat. by account 1° 13′ S., long. 84° 6′ W., the following times at equal altitudes of the sun near noon were observed to determine the longitude:—

	h.	m.	s.
Time A.M.	1	1	42
„ P.M.	1	12	0
2)	2	13	42
	1	6	51
Equation of Time applied as to Mean Time	—	2	32
Watch time of ship mean noon ...	1	4	19
Watch slow on Greenwich	4	33	36
Greenwich time at ship mean noon	5	37	55 = long. 84° 28′ 45″ W.

The sun being most probably the only object employed in this way, the equation of equal altitudes, if required, may be computed and applied precisely as if the ship had been at rest; but as the greatest change in the sun's declination in one hour is about one minute, and the change of latitude is generally much greater, the equation of equal altitudes is commonly neglected as relatively unimportant in a method which at sea is necessarily but approximate.

Longitude from Observations at Sunrise or Sunset.*

It often happens that the sun is visible for a short time after rising or before setting, although obscured for the remainder of the day, thus giving the sailor an opportunity of obtaining the true time from which he may ascertain the longitude.

The foregoing remarks upon the terrestrial refraction, and the height of waves, will show that this method can only be an approximation; yet as such an approximation before nightfall, or after the night's run, may prove useful, the following have been drawn up for the use of the navigator:—

Sun's Semi-diameter.	Height of eye, 13 feet.		Height of eye, 21 feet.	
	Altitude of Upper Limb.	Altitude of Lower Limb.	Altitude of Upper Limb.	Altitude of Lower Limb.
15′ 45″	45′ 55′	18′ 20″	46′ 55″	19′ 20″
15 50	46 0	18 15	46 59	19 15
15 55	46 5	18 10	47 2	19 10
16 0	46 9	18 6	47 6	19 5
16 5	46 13	18 3	47 10	19 0
16 10	46 17	17 59	47 15	18 55
16 15	46 20	17 55	47 20	18 50

The altitude taken from the above table according to the height of the eye, corrected inversely for the index error, is to be placed upon the sextant; the observer should watch the rising or setting sun until the altitude is on, and then note the time by chronometer. The upper limb should be preferred. A second observer might at the same time take the lower limb.

Rule.—To the log. tan. of the lat. add the log. tan. of the sun's declination, and the sum, rejecting 10 from the index, will be the log. sin. of an arc, which take from the tables in time. If the latitude and declination are of the same name, add this time to 6^h at sunset, and subtract it from 6^h at sunrise.

* Tables for finding by inspection the Longitude by Chronometer at sunrise or sunset, by *Com. H. Weston, I.N.*, are published by the Admiralty Hydrographic Office.

If the latitude and declination are of different names, add the time found to 6^h at sunrise and subtract it from 6^h at sunset.

To the time so found, which is apparent time, apply the Equation of Time; and the result will be ship mean time.

Example.

August 30th, 1876, in lat. 18° 43′ S., the sun set at $3^h\ 21^m\ 8^s$ Greenwich mean time, required the longitude.

Dec.	8° 45′ N.	Log. tan. 9·1873
Lat.	18° 43′ S.	Log. tan. 9·5300
	h. m. s.	
	− 0 11 58	Log. sin. 8·7173
	6 0 0	
	5 48 02	
Equation of time	+ 19	
Ship mean time	5 48 21	
Greenwich mean time	3 21 8	
Long. in time	2 27 13 = 36° 48′ 15″ E.	

N.B.—This method should be used only between the parallels of 40° N. and 40° S.

To Find the Apparent Time to Fire the Daylight Gun.

Daybreak, or the commencing of morning twilight, occurs after the sun has crossed the crepusculum, or twilight circle, which is 18° below the horizon.

RULE.

Under the latitude put the declination, marking them with their proper names N. or S.; if the names are alike, take the difference; if unlike, take the sum; and under this put the constant angle 108°; take the sum and difference. Add together the log. secants of the two first terms (rejecting the

tens in the index), and the half log. haversines of the two last. With the sum as a log. haversine, take out the corresponding angle in time at the top of the page, which will be the ending of evening twilight, and which, subtracted from twelve hours, will give the beginning of morning twilight, or daylight, in *apparent time.*

Lat. 22° 17′ N.	Log. sec. 0·0337
Dec. 15° 3′ N.	Log. sec. 0·0151
7 14	
108	
115 14	½ log. hav. 4·9266
100 46	½ log. hav. 4·8867
	Log. hav. 9·8621

	H.	M.	
Evening twilight ends	7	49	Apparent time.
	12	0	
	4	11	Morning twilight begins.

Using a Terrestrial Globe.

This problem may also be readily solved by the help of a globe, as follows: Rectify the globe for the latitude, zenith, and noon; then turn the globe, so as to make the sun's place on the ecliptic coincide with 18°, marked upon the quadrant of altitude *below the horizon.* The hour circle will then show the *apparent time* of the beginning of twilight, if the contact is made in the eastern hemisphere; and of the end of twilight if the contact is made in the western hemisphere.

To Find the Apparent Time of Sunset.

See ordinary Nautical Tables; or Burdwood's Azimuth Tables between lat. 30° and 60°; and Davis' Azimuth Tables between lat. 30° and the Equator.

Horizon Method of ascertaining from a Fort, or Ship, the Distance of an Enemy's Ship.

When the height of the enemy's masthead above her water line is known, the Table of Masthead Angles will give the distance; but in the case of monitors without masts, gun-boats, mortar-boats, etc., this method is not available.

If there are two forts sufficiently far apart to allow of the distance between them forming a base of sufficient length, and telegraphic communication is established between the forts, then Professor Sieman's Table, on which a chart of the approach, subdivided into small squares, is placed, will show with great accuracy the exact position of the enemy's ship; it will be at the intersection of two rulers, one of which is controlled by a telescope pointing at the enemy's ship at one fort, and the other ruler at the same fort is by electricity constrained to follow exactly and be parallel to the direction of the telescope at the other fort, also kept pointing at the enemy. This Table may be usefully employed for torpedo purposes as well as for gunnery.

In the absence of such a table, the bearing of the enemy and the changes in it may be telegraphed from one fort to another and pencilled on a chart.

If there is no second fort or suitable position for a second observer, and the enemy is mastless, the distance from the enemy may be found from the dip angle, observed with a theodolite, or a method styled by its inventor (Admiral Sir A. P. Ryder, K.C.B.) the "horizon" method* may be found useful (if there is no theodolite), by the aid of a sextant or pocket sextant, provided the horizon is in sight above the ship. This method was more especially designed for use on board ship, but it is equally available on shore.

Every fort should have its own "horizon" table calculated and hung up, the difference being due to the varying height.

Table IV. in Admiral Ryder's work has been calculated especially for this method, in which the angle subtended between the horizon and the enemy's water line is ascertained by an observer aloft, or if on shore, from a fort (the higher the better); and is corrected by the addition of the dip angle due to the height.

* This method was first suggested and the table prepared in June, 1841, by Lieut. A. P. Ryder. It has been adopted in foreign navies and found useful. One copy is officially supplied to each of our men-of-war.

Table IV. cannot be abbreviated, but up to a certain point it is nearly identical with Table III. in the same work, and therefore with the following table, of "Masthead Angles—Height 20 feet," which has been abbreviated from Table III. by Admiral Ryder, for the Sailor's Pocket Book. Although Table III. ends by diverging widely from Table IV., nevertheless, for naval gunnery purposes, viz. range *at sea*, the error is not very material—its limit is as follows:—

When the observer is at a height above the water of		The error introduced by using Table III. in Admiral Ryder's work, or Table I. in the Pocket Book instead of Table IV. in Admiral Ryder's work, will not exceed 100 yards until the distance exceeds	
50 feet.			2000 yards.
100 ,,			3000 ,,
150 ,,			4060 ,,
200 ,,			4700 ,,

For greater distances or lower heights, or if an error of 100 yards is too great, as may be the case for "fuze cutting," recourse must be had to Admiral Ryder's work. This abbreviated table is sufficiently compact to allow of its being copied into the watch-bill.

Example.—(1) Let the angle subtended between the horizon and the enemy's water-line, ascertained by an observer at the *Sultan's* crosstrees, or the fort in Drake's Island (say a height of 205 feet), be 2°. Required the distance:—

The dip of the horizon due to a height of 205 feet (see Dip Table) is 15′ 11″; 2° + 15′ 11″ = 2° 15′, neglecting the seconds.

The distance due to an angle of 2° 15′, if the height had been 20 feet, would have been, from Masthead Angle Table, column 2, 169 yards. The correction for each foot of additional height, column 3, is 8·5 yards.

Distance = 169 + (205 − 20) 8·5 = 1741 yards.

This is a sufficiently close approximation to the distance given in Table IV. in Admiral Ryder's work, viz. 1743 yards, showing that the Masthead Angle Table in the Sailor's Pocket Book can be safely used with the "horizon" method, within the prescribed limits.

Example.—(2) Let the angle subtended between the horizon and the enemy's water line, ascertained by an observer in the *Devastation's* tc or the upper battery in the Breakwater fort (say 95 feet above the wate *be 9′.*

The dip of the horizon due to a height of 95 feet (see Dip Table) is 10′ 19″; 9′ + 10′ = 19′, neglecting the seconds.

The distance due to an angle of 19′, if the height had been 20 feet, would have been, from the Masthead Angle Table, column 2, 1204 yards.

The correction for each foot of additional height, column 3, is 60·3 yards; distance = 1204 + (95 − 20) 60·3 = 5726 yards.

On ascertaining the distance for the same height and angle from Table IV. in Admiral Ryder's work, it will be found to be 7229 yards, showing an error of 1503 yards, introduced by using the Masthead Angle Table with the "horizon" method beyond the prescribed limits.

This example is given to enforce the necessity of confining the use of the Masthead Angle Table for the "horizon" method, to the limits laid down above.

Of course, if there is any index correction it must be applied, but it will be found more convenient and less embarrassing to the observer aloft to use a sextant that has no index error.

A. P. R.

Dip Table.

Height of eye above water in feet.	Amount of dip.	Height of eye above water in feet.	Amount of dip.	Height of eye above water in feet.	Amount of dip.
	′ ″		′ ″		′ ″
20	4·40	85	9·45	150	13 ·0
25	5·11	90	10 ·3	155	13·13
30	5·43	95	10·19	160	13·27
35	6·11	100	10·35	165	13·39
40	6·40	105	10·51	170	13·51
45	7 ·5	110	11 ·7	175	14 ·3
50	7·30	115	11·22	180	14·15
55	7·51	120	11·38	185	14·26
60	8·12	125	11·52	190	14·38
65	8·32	130	12 ·6	195	14·49
70	8·52	135	12·19	200	15 ·1
75	9·10	140	12·33	205	15·11
80	9·28	145	12·46	210	15·22

NOTE.—This differs from the Dip Table, Section V., in that it has not been corrected for refraction.

R.

Masthead Angles.—Height 20 feet.

Masthead Angle.	Distance in yards.	Correction for 1 foot in height.	Masthead Angle.	Distance in yards.	Correction for 1 foot in height.	Masthead Angle.	Distance in yards.	Correction for 1 foot in height.	Masthead Angle.	Distance in yards.	Correction for 1 foot in height.
° ′	yds.	yds.	° ′	yds.	yds.	° ′	yds.	yds.	° ′	yds.	yds.
5 0	76	3·8	1 52	204	10·2	1 4	358	17·9	0 38	602	30·2
4 30	85	4·2	1 50	208	10·4	1 2	369	18·5	0 37	618	31·0
4 0	95	4·8	1 48	212	10·6	1 0	382	19·1	0 36	636	31·8
3 50	99	5·0	1 46	216	10·8	0 59	388	19·4	0 35	654	32·2
3 40	104	5·2	1 44	220	11·0	0 58	395	19·7	0 34	673	33·7
3 30	109	5·4	1 42	224	11·2	0 57	402	20·1	0 33	694	34·7
3 20	114	5·7	1 40	229	11·4	0 56	409	20·5	0 32	715	35·8
3 10	120	6·5	1 38	234	11·7	0 55	416	20·8	0 31	739	37·0
3 0	127	6·4	1 36	238	11·9	0 54	424	21·2	0 30	763	38·2
2 55	131	6·5	1 34	243	12·2	0 53	432	21·6	0 29	790	39·5
2 50	135	6·7	1 32	249	12·5	0 52	440	22·0	0 28	818	40·9
2 45	139	6·9	1 30	254	12·7	0 51	449	22·5	0 27	848	42·4
2 40	143	7·1	1 28	260	13·0	0 50	458	22·9	0 26	881	44·1
2 35	148	7·4	1 26	266	13·3	0 49	467	23·4	0 25	916	45·8
2 30	152	7·6	1 24	273	13·6	0 48	477	23·9	0 24	954	47·7
2 25	158	7·9	1 22	279	14·0	0 47	487	24·4	0 23	997	49·8
2 20	163	8·2	1 20	286	14·3	0 46	498	25·0	0 22	1041	52·1
2 15	169	8·5	1 18	293	14·7	0 45	509	25 5	0 21	1090	54·6
2 10	176	8·8	1 16	301	15·1	0 44	520	26·0	0 20	1145	57·3
2 5	183	9·2	1 14	309	15·5	0 43	532	26·6	0 19	1204	60·3
2 0	191	9·5	1 12	318	15·6	0 42	545	27·3	0 18	1272	63·6
1 58	194	9·7	1 10	327	16·4	0 41	558	28 0	0 17	1347	67·4
1 56	197	9·9	1 8	337	16·8	0 40	572	28·9	0 16	1431	71·6
1 54	201	10·0	1 6	347	17·4	0 39	587	29·4	0 15	1526	76·4

TABLE OF MASTHEAD ANGLES.

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	80 Feet.	85 Feet.	90 Feet.	95 Feet.	100 Feet.	105 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
¼	100	14 55 53	15 49 10	16 41 57	17 34 17	18 26 6	19 17 23
⅜	150	10 4 51	10 41 48	11 18 36	11 55 15	12 31 44	13 8 2
1	200	7 35 40	8 3 48	8 31 51	8 59 50	9 27 44	9 55 34
1¼	250	6 5 19	6 27 57	6 50 34	7 13 8	7 35 40	7 58 16
¼	300	5 4 46	5 23 43	5 42 38	6 1 32	6 20 25	6 39 16
⅜	350	4 21 25	4 37 42	4 53 57	5 10 12	5 26 25	5 42 39
2	400	3 48 51	4 3 6	4 17 21	4 31 35	4 45 49	5 0 2
¼	450	3 23 28	3 36 10	3 48 51	4 1 31	4 14 11	4 26 51
¼	500	3 3 11	3 14 36	3 26 1	3 37 26	3 48 50	4 0 15
⅜	550	2 46 33	2 56 57	3 7 20	3 17 43	3 28 6	3 38 28
3	600	2 32 41	2 42 13	2 51 45	3 1 16	3 10 47	3 20 19
¼	650	2 20 57	2 29 45	2 38 33	2 47 21	2 56 8	3 4 56
¼	700	2 10 54	2 19 5	2 27 15	2 35 25	2 43 35	2 51 44
⅜	750	2 2 11	2 9 49	2 17 26	2 24 4	2 32 41	2 40 19
4	800	1 54 33	2 1 43	2 8 51	2 25 0	2 23 9	2 30 18
¼	850	1 47 49	1 54 33	2 1 17	2 8 0	2 14 45	2 21 28
¼	900	1 41 50	1 48 12	1 54 33	2 0 54	2 7 16	2 13 37
⅜	950	1 36 28	1 42 30	1 48 32	1 54 33	2 0 34	2 6 36
5	1000	1 31 39	1 37 23	1 43 6	1 48 50	1 54 33	2 0 16
¼	1050	1 27 17	1 32 45	1 38 12	1 43 59	1 49 6	1 54 33
¼	1100	1 23 19	1 28 32	1 33 44	1 38 57	1 44 8	1 49 21
⅜	1150	1 19 42	1 24 41	1 29 40	1 34 39	1 39 37	1 44 35

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

Table of Masthead Angles—(*continued*).

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	80 Feet.	85 Feet.	90 Feet.	95 Feet.	100 Feet.	105 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
6	1200	1 16 23	1 21 10	1 25 56	1 30 42	1 35 28	1 40 14
¼	1250	1 13 20	1 17 54	1 22 29	1 27 3	1 31 39	1 36 14
¼	1300	1 10 31	1 14 55	1 19 19	1 23 43	1 28 8	1 32 32
¼	1350	1 7 54	1 12 8	1 16 23	1 20 37	1 24 52	1 29 5
7	1400	1 5 28	1 9 34	1 13 39	1 17 45	1 21 50	1 25 56
¼	1450	1 3 13	1 7 10	1 11 7	1 15 4	1 19 1	1 22 58
¼	1500	1 1 7	1 4 56	1 8 45	1 12 34	1 16 23	1 20 12
¼	1550	0 59 8	1 2 50	1 6 32	1 10 13	1 13 55	1 17 37
8	1600	0 57 18	1 0 52	1 4 27	1 8 2	1 11 37	1 15 11
¼	1650	0 55 33	0 59 2	1 2 30	1 5 58	1 9 26	1 12 55
¼	1700	0 53 55	0 57 17	1 0 39	1 4 2	1 7 24	1 10 46
¼	1750	0 52 23	0 55 39	0 58 55	1 2 12	1 5 28	1 8 45
9	1800	0 50 56	0 54 7	0 57 18	1 0 28	1 3 39	1 6 50
¼	1850	0 49 33	0 52 39	0 54 44	0 58 50	1 1 56	1 5 1
¼	1900	0 48 15	0 51 16	0 54 16	0 57 17	1 0 18	1 3 19
¼	1950	0 47 1	0 49 57	0 52 53	0 55 49	0 58 46	1 1 42
1 Mile	2000	0 45 50	0 48 42	0 51 34	0 54 26	0 57 17	1 0 9
¼	2500	0 36 40	0 38 57	0 41 15	0 43 32	0 45 50	0 48 7
¼	3000	0 30 34	0 32 28	0 34 23	0 36 17	0 38 12	0 40 6
¼	3500	0 26 12	0 27 50	0 29 28	0 31 6	0 32 44	0 34 23
2	4000	0 22 55	0 24 21	0 25 47	0 27 13	0 28 39	0 30 5
¼	4500	0 20 22	0 21 39	0 22 55	0 24 11	0 25 28	0 26 44
¼	5000	0 18 20	0 19 29	0 20 38	0 21 46	0 22 55	0 24 4
¼	5500	0 16 40	0 17 43	0 18 45	0 19 48	0 20 50	0 21 52
3	6000	0 15 16	0 16 14	0 17 11	0 18 8	0 19 6	0 20 3

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

Table of Masthead Angles—(*continued*).

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	110 Feet.	115 Feet.	120 Feet.	125 Feet.	130 Feet.	135 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
¼	100	20 8 11	20 58 24	21 48 5	22 37 12	23 25 43	24 13 40
¾	150	13 44 11	14 20 7	14 55 54	15 31 28	16 6 49	16 41 58
1	200	10 23 20	10 51 0	11 18 36	11 46 6	12 13 30	12 40 49
¼	250	8 20 38	8 43 4	9 5 25	9 27 45	9 50 1	10 12 14
¾	300	6 58 6	7 16 54	7 35 41	7 54 26	8 13 9	8 31 51
¾	350	5 58 50	6 15 2	6 31 12	6 47 21	7 3 28	7 19 35
2	400	5 14 15	5 28 27	5 42 39	5 56 49	6 10 58	6 25 8
½	450	4 39 30	4 52 8	5 4 47	5 17 25	5 30 1	5 42 39
¾	500	4 11 39	4 23 4	4 34 26	4 45 49	4 57 12	5 8 34
¾	550	3 38 51	3 59 13	4 9 35	4 19 57	4 30 18	4 40 39
3	600	3 29 49	3 39 20	3 48 51	3 58 21	4 7 51	4 17 21
½	650	3 13 43	3 22 30	3 31 17	3 40 4	3 48 51	3 57 37
¾	700	2 59 55	3 8 4	3 16 14	3 24 23	3 32 32	3 40 42
¾	750	2 47 56	2 55 33	3 3 10	3 10 47	3 18 24	3 26 1
4	800	2,37 27	2 44 36	2 51 45	2 58 54	3 6 2	3 13 10
½	850	2 28 12	2 34 56	2 41 40	2 48 23	2 55 7	3 1 50
¾	900	2 19 59	2 26 20	2 32 41	2 39 2	2 45 23	2 51 45
¾	950	2 12 37	2 18 38	2 24 40	2 30 41	2 36 42	2 42 43
5	1000	2 6 0	2 11 43	2 17 26	2 23 9	2 28 53	2 34 36
¼	1050	2 0 0	2 5 27	2 10 54	2 16 21	2 21 48	2 27 15
¾	1100	1 54 33	1 59 45	2 4 57	2 10 10	2 15 21	2 20 33
¾	1150	1 49 33	1 54 33	1 59 32	2 4 30	2 9 28	2 14 27
6	1200	1 45 1	1 49 47	1 54 33	1 59 19	2 4 5	2 8 51
¼	1250	1 40 49	1 45 23	1 49 58	1 54 33	1 59 8	2 3 43
¾	1300	1 36 56	1 41 20	1 45 45	1 50 9	1 54 33	1 58 57
¾	1350	1 33 21	1 37 35	1 41 50	1 46 4	1 50 18	1 54 33

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on* and *off* the arc of the sextant, and the mean will give angle free of index error.

Table of Masthead Angles—(*continued*).

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	110 Feet.	115 Feet.	120 Feet.	125 Feet.	130 Feet.	135 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
7	1400	1 30 1	1 34 6	1 38 12	1 42 17	1 46 22	1 50 28
¼	1450	1 26 55	1 30 52	1 34 49	1 38 46	1 42 43	1 46 40
¼	1500	1 24 1	1 27 50	1 31 39	1 35 28	1 39 17	1 43 6
¼	1550	1 21 19	1 25 0	1 28 42	1 32 23	1 36 5	1 39 46
8	1600	1 18 46	1 22 21	1 25 56	1 29 30	1 33 5	1 36 40
¼	1650	1 16 23	1 19 51	1 23 19	1 26 48	1 30 16	1 33 44
¼	1700	1 14 8	1 17 30	1 20 53	1 24 15	1 27 37	1 30 59
¼	1750	1 12 1	1 15 17	1 18 34	1 21 50	1 25 6	1 28 23
9	1800	1 10 1	1 13 12	1 16 23	1 19 34	1 22 45	1 25 56
¼	1850	1 8 7	1 11 13	1 14 19	1 17 25	1 20 30	1 23 36
¼	1900	1 6 20	1 9 21	1 12 22	1 15 23	1 18 23	1 21 24
¼	1950	1 4 38	1 7 34	1 10 31	1 13 27	1 16 23	1 19 19
1 Mile	2000	1 3 1	1 5 53	1 8 45	1 11 36	1 14 28	1 17 20
¼	2500	0 50 25	0 52 42	0 55 0	0 57 17	0 59 35	1 1 52
¼	3000	0 42 1	0 43 56	0 45 50	0 47 45	0 49 39	0 51 34
¼	3500	0 36 1	0 37 39	0 39 17	0 40 56	0 42 34	0 44 12
2	4000	0 31 31	0 32 57	0 34 23	0 35 48	0 37 14	0 38 40
¼	4500	0 28 1	0 29 17	0 30 33	0 31 50	0 33 6	0 34 23
¼	5000	0 25 12	0 26 21	0 27 30	0 28 39	0 29 48	0 30 56
¼	5500	0 22 55	0 23 58	0 25 0	0 26 3	0 27 5	0 28 8
3	6000	0 21 0	0 21 58	0 22 55	0 23 52	0 24 50	0 25 47

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

Table of Masthead Angles—(*continued*).

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	140 Feet.	145 Feet.	150 Feet.	155 Feet.	160 Feet.	165 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
¼	100	25 1 0	25 47 46	26 33 54	27 19 26	28 4 21	28 48 39
¾	150	17 16 55	17 51 37	18 26 6	19 0 22	19 34 24	20 8 10
1	200	13 8 2	13 35 10	14 2 11	14 29 5	14 55 53	15 22 35
¼	250	10 34 25	10 56 32	11 18 36	11 40 36	12 2 33	12 24 27
¼	300	8 50 30	9 9 9	9 27 44	9 46 18	10 4 50	10 23 20
¾	350	7 35 40	7 51 46	8 7 49	8 23 51	8 39 51	8 55 50
2	400	6 39 16	6 53 24	7 7 30	7 21 36	7 35 40	7 49 44
¼	450	5 55 14	6 7 50	6 20 25	6 33 0	6 45 33	6 58 6
¼	500	5 19 56	5 31 17	5 42 39	5 53 59	6 5 19	6 16 38
¾	550	4 50 59	5 1 20	5 11 40	5 22 0	5 32 19	5 42 39
3	600	4 26 51	4 36 21	4 45 49	4 55 18	5 4 47	5 14 15
¼	650	4 6 23	4 15 10	4 23 55	4 32 41	4 41 26	4 50 12
¼	700	3 48 51	3 57 0	4 5 8	4 13 17	4 21 25	4 29 33
¾	750	3 33 38	3 41 14	3 48 51	3 56 27	4 4 3	4 11 39
4	800	3 20 19	3 27 27	3 34 35	3 41 42	3 48 51	3 55 58
¼	850	3 8 33	3 15 16	3 21 59	3 28 42	3 35 25	3 42 8
¼	900	2 58 6	3 4 27	3 10 47	3 17 8	3 23 29	3 29 50
¾	950	2 48 44	2 54 45	3 0 46	3 6 47	3 12 48	3 18 48
5	1000	2 40 19	2 46 2	2 51 45	2 57 28	3 3 10	3 8 53
¼	1050	2 32 41	2 38 8	2 43 35	2 49 1	2 54 28	2 59 55
¼	1100	2 25 45	2 30 57	2 36 9	2 41 21	2 46 33	2 51 45
¾	1150	2 19 26	2 24 24	2 29 22	2 34 21	2 39 19	2 44 17
6	1200	2 13 27	2 18 24	2 23 9	2 27 55	2 32 41	2 37 27
	1250	2 8 17	2 12 52	2 17 26	2 22 1	2 26 35	2 31 10
¼	1300	2 3 21	2 7 46	2 12 9	2 16 33	2 20 57	2 25 21
¾	1350	1 58 47	2 3 2	2 7 16	2 11 30	2 15 45	2 19 59

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

Table of Masthead Angles—(*continued*).

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	140 Feet.	145 Feet.	150 Feet.	155 Feet.	160 Feet.	165 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
7	1400	1 54 33	1 58 39	2 2 43	2 6 49	2 10 54	2 14 59
¼	1450	1 50 36	1 54 33	1 58 30	2 2 27	2 6 23	2 10 20
½	1500	1 46 55	1 50 44	1 54 33	1 58 22	2 2 11	2 6 0
¾	1550	1 43 28	1 47 10	1 50 51	1 54 33	1 58 14	2 1 56
8	1600	1 40 12	1 43 49	1 47 24	1 50 58	1 54 33	1 58 8
¼	1650	1 37 12	1 40 40	1 44 8	1 47 37	1 51 5	1 54 33
½	1700	1 34 21	1 37 43	1 41 5	1 44 27	1 47 49	1 51 11
¾	1750	1 31 39	1 34 56	1 38 12	1 41 28	1 44 44	1 48 0
9	1800	1 29 6	1 32 17	1 35 28	1 38 39	1 41 50	1 45 1
¼	1850	1 26 42	1 29 48	1 32 53	1 35 59	1 39 5	1 42 10
½	1900	1 24 25	1 27 26	1 30 27	1 33 28	1 36 28	1 39 29
¾	1950	1 22 15	1 25 12	1 28 8	1 31 4	1 34 0	1 36 56
1 Mile	2000	1 20 12	1 23 4	1 25 56	1 28 47	1 31 39	1 34 31
¼	2500	1 4 10	1 6 27	1 8 45	1 11 2	1 13 20	1 15 37
½	3000	0 53 28	0 55 23	0 57 17	0 59 12	1 1 6	1 3 1
¾	3500	0 45 50	0 47 28	0 49 7	0 50 45	0 52 23	0 54 1
2	4000	0 40 6	0 41 32	0 42 58	0 44 24	0 45 50	0 47 16
¼	4500	0 35 39	0 36 55	0 38 12	0 39 28	0 40 45	0 42 1
½	5000	0 32 5	0 33 14	0 34 23	0 35 31	0 36 40	0 37 49
¾	5500	0 29 10	0 30 13	0 31 15	0 32 18	0 33 20	0 34 23
3	6000	0 26 55	0 27 42	0 28 39	0 29 36	0 30 33	0 31 31

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

Table of Masthead Angles—(*continued*).

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	170 Feet.	175 Feet.	180 Feet.	185 Feet.	190 Feet.	195 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1/4	100	29 32 19	30 15 21	30 57 50	31 39 30	32 20 51	33 1 25
1/3	150	20 41 44	21 15 1	21 48 6	22 20 54	22 53 26	23 25 43
1	200	15 49 9	16 15 36	16 41 57	17 8 11	17 34 17	18 0 15
1/4	250	12 46 16	13 8 2	13 29 45	13 51 23	14 12 57	14 34 27
1/3	300	10 41 47	11 0 12	11 18 36	11 36 56	11 55 15	12 13 30
1/2	350	9 11 48	9 27 44	9 43 40	9 59 34	10 15 25	10 31 15
2	400	8 3 47	8 17 49	8 31 51	8 45 51	8 59 50	9 13 47
1/4	450	7 10 38	7 23 9	7 35 41	7 48 11	8 0 40	8 13 9
1/3	500	6 27 57	6 39 16	6 50 34	7 1 51	7 13 9	7 24 25
1/2	550	5 53 57	6 3 15	6 13 33	6 23 51	6 34 8	6 44 24
3	600	5 23 43	5 33 10	5 42 38	5 52 5	6 1 32	6 10 58
1/4	650	4 58 57	5 7 42	5 16 26	5 25 11	5 33 54	5 42 39
1/3	700	4 37 41	4 45 49	4 53 57	5 2 4	5 10 11	5 18 18
1/2	750	4 19 15	4 26 50	4 34 26	4 42 2	4 49 37	4 57 12
4	800	4 3 6	4 10 13	4 17 21	4 24 28	4 31 35	4 38 42
1/4	850	3 48 51	3 55 33	4 2 16	4 8 58	4 15 40	4 22 22
1/3	900	3 36 10	3 42 30	3 48 51	3 55 11	4 1 31	4 7 51
1/2	950	3 24 49	3 30 49	3 36 50	3 42 51	3 48 51	3 54 51
5	1000	3 14 36	3 20 19	3 26 1	3 31 44	3 37 26	3 43 8
1/4	1050	3 5 21	3 10 47	3 16 14	3 21 40	3 27 6	3 32 32
1/3	1100	2 56 56	3 2 8	3 7 20	3 12 31	3 17 43	3 22 54
1/2	1150	2 49 17	2 54 14	2 59 12	3 4 10	3 9 8	3 14 6
6	1200	2 42 13	2 46 59	2 51 45	2 56 30	3 1 16	3 6 0
1/4	1250	2 35 44	2 40 19	2 44 53	2 49 28	2 54 2	2 58 36
1/3	1300	2 29 45	2 34 9	2 38 33	2 42 57	2 47 21	2 51 45
1/2	1350	2 24 13	2 28 27	2 32 41	2 36 56	2 41 9	2 45 24

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

Table of Masthead Angles—(*continued*).

Distance in		HEIGHT OF MASTHEAD.					
Cables.	Yards.	170 Feet.	175 Feet.	180 Feet.	185 Feet.	190 Feet.	195 Feet.
		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
7	1400	2 19 4	2 23 9	2 27 15	2 31 20	2 35 25	2 39 28
¼	1450	2 14 17	2 18 14	2 22 10	2 26 7	2 30 4	2 34 0
⅛	1500	2 9 48	2 13 37	2 17 26	2 21 15	2 25 4	2 28 53
⅜	1550	2 5 37	2 9 19	2 13 1	2 16 42	2 20 23	2 24 5
8	1600	2 1 42	2 5 17	2 8 52	2 12 26	2 16 1	2 19 35
¼	1650	1 58 1	2 1 29	2 4 57	2 8 25	2 11 53	2 15 22
⅛	1700	1 54 33	1 57 55	2 1 17	2 4 39	2 8 1	2 11 23
⅜	1750	1 51 16	1 54 33	1 57 49	2 1 5	2 4 21	2 7 38
9	1800	1 48 12	1 51 22	1 54 33	1 57 44	2 0 54	2 4 5
¼	1850	1 45 16	1 48 22	1 51 27	1 54 33	1 57 39	2 0 44
⅛	1900	1 42 30	1 45 31	1 48 31	1 51 32	1 54 33	1 57 34
⅜	1950	1 39 52	1 42 38	1 45 45	1 48 41	1 51 37	1 54 33
1 Mile.	2000	1 37 22	1 40 14	1 43 6	1 45 58	1 48 50	1 51 41
½	2500	1 17 55	1 20 12	1 22 30	1 24 47	1 27 4	1 29 22
½	3000	1 4 56	1 6 50	1 8 45	1 10 39	1 12 34	1 14 28
½	3500	0 55 39	0 57 17	0 58 56	1 0 34	1 2 12	1 3 50
2	4000	0 48 42	0 50 8	0 51 34	0 53 0	0 54 26	0 55 52
½	4500	0 43 17	0 44 34	0 45 50	0 47 7	0 48 23	0 49 39
⅛	5000	0 38 58	0 40 6	0 41 15	0 42 24	0 43 33	0 44 41
⅜	5500	0 35 25	0 36 28	0 37 30	0 38 33	0 39 35	0 40 38
3	6000	0 32 28	0 33 25	0 34 23	0 35 20	0 36 17	0 37 15

NOTE.—When observed Masthead Angles are not more than 5° they should be taken both *on and off* the arc of the sextant, and the mean will give angle free of index error.

The Following are the Heights from Main Truck to Hammock Netting of Ships representing the different classes of Vessels in the Navy.

Name.	Class.	Height.	Height of Hammock Netting.
		Feet.	
ACHILLES	Ironclad.	166	
ALEXANDRA	„	149	
HERCULES	„	173	
„ with topgallant masts struck	„	151	23
INVINCIBLE	„	156	
LORD WARDEN	„	155	
MINOTAUR	„	149	
INCONSTANT	Frigate (*iron, wood-cased*).	168	23½
IRIS	Despatch vessel.	123	
VOLAGE	Corvette (*iron, wood-cased*).	130	
CARYSFORT	Corvette (*steel and iron, wood-cased*).	117	
PELICAN	Sloop (*composite*).	94	9½
DECOY	Gun-boat (*composite*).	72	9½

The following are the Heights from the Truck of the highest Mast to the Deck of some representative Ships of the Mercantile Marine.

Name of Ship.	Line or Company.	Height.
		Feet.
PARISIAN	ALLAN	121
FURNESSIA	ANCHOR	129
SERVIA	CUNARD	118
ALASKA	GUION	113
CITY OF BERLIN	INMAN	132
AUSTRAL	ORIENT	133
COTOPAXI	PACIFIC	104
VALETTA	PENINSULAR AND ORIENTAL	118
ATHENIAN	UNION	149
BRITANNIA	WHITE STAR	116

Finding Distance of a Target at Sea.

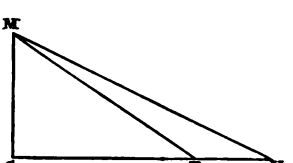
Example.

MS, height of main-top.

THM, observed angle between the target and the horizon.

SHM, dip.

STM = dip + observed angle.



The distance a vessel is off when seen from the masthead of another vessel, may be roughly calculated by using the *Table showing the distance of the horizon at different elevations* (see page 260), in the following manner :—

Suppose height of observer's masthead to be 150 feet. A sail is seen from it, with half her topsails visible above the horizon.

An estimate must be formed of the height of half her topsails—say 70 feet.

Height of 70 feet makes the horizon at that height, as 9½ miles distant; and of 150 feet (height of observer's masthead), 14 miles: total distance between the two vessels, 23½ miles.

Raper's Method of Determining Distances at Sea.

The distance of high land, whose height is known, may be found by measuring its altitude with a sextant.

When angles observed with the sextant are not more than 5°, they should be taken both on and off the arc, added together, and divided by 2. The result is an angle free of index error.

Rule.—To the log. cos. of the dip of the height of the summit observed, add the log. cos. of the difference between the altitude and the dip of the spectator. The sum is the log. cos. of an arc, from which subtract the said difference, and the remainder is the distance in miles, or minutes of a degree.

NOTE.—The altitude must exceed the dip of the spectator.

Example.—The summit of Mount Etna is observed to be 1° 30′ above the horizon; the height of the eye 20 feet. Required the distance.

Log. cos. dip of Mount Etna *.....	9·999774
Log. cos. (1° 30′ − 4′ 17″) = 1° 26′.....	9·999864
2° 20′ Log. cos.....	9·999638
− 1 26	

54 miles approximate distance.

* The log. cos. of the dip of some principal points of high land are here given for convenience, and the log. of any intermediate height may be found by simple proportion.

Peak of Teneriffe (12,172)	9·999747
Mount Etna (10,885)	9·999774
St. Antonio, Cape Verde Is. (7398)	9·999846
Mount Athos (6774)	9·999859
Pico Ruivo, Madeira (6188)	9·999872
Mount Ida (5800)	9·999879
Black Mountain, Cephalonia (5382)	9·999888
Volcano, Guadaloupe (5108)	9·999894
Table Mountain, Cape of Good Hope (3904)	9·999910
Mount Vesuvius (3878)	9·999920
Diana Peak, St. Helena (2687)	9·999944
Mount St. Peter, Ascension (2217)	9·999954
Rock of Gibraltar (1437)	9·999970

The summit and the horizon being both raised by refraction in proportion to their distances, the altitude must be corrected by this rule.

Subtract from the altitude observed, one-twelfth of the distance, and add to the remainder one-twelfth of the dip.

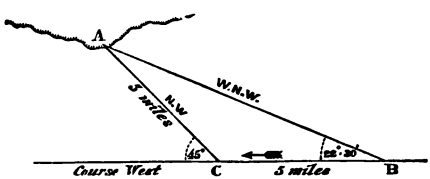
Here one-twelfth of 54 miles, or 4′ 30″, being taken from 1° 30′; and one-twelfth of 5′, or 25″, being added, gives the true altitude 1° 25′ 55″; the sum worked over again with this altitude gives the distance 56 miles, which is near enough for ordinary purposes.

But it is near enough, in most cases, to estimate the distance, and correct the altitude at once. Thus, an error of upwards of four leagues in the estimated distance will not, in the present example, produce an error of one mile in the calculated distance.

The following is a useful Method of Determining Distance approximately from a Lighthouse or other object, when running along the land.

Take a bearing of the object, and note the time; see how many points it differs from the course; when this difference is doubled, the ship will be as far from the object as she has run in the interval.

N.B.—Make due allowance for current.



Example.—Steering West, going 10 knots, at 9 45 a.m. a lighthouse, A, bore W.N.W. Difference between bearing and course = 2 points. Stood (on until it bore N.W. double the difference), time 10·15 a.m.

Distance run = 5 miles = distance of lighthouse. See also table at page 261.

Measuring Distances by Sound.

Sound travels at the rate of 1090 feet in a second of time, when the air is at freezing point, or 32° of Fahrenheit.

[redacted]his rate is accelerated by 1·19 feet for each degree of Fahrenheit above

that temperature, giving 1123 feet (or 374 yards) velocity per second, for a mean temperature of 60°, which may be used for all ordinary purposes.

Example.

	h.	m.	s.
Observed flash of gun at.....	8	25	33
Heard report.....	8	25	40
	0	0	7

$374 \times 7 = 2618$ yards.

Or, using acceleration, thermometer showing 80° Fahrenheit—

80°	At 32° sound travels	1090 feet (per sec.)
32°	1·19 acceleration × 48.....	57 „
Diff. 48°	At 80 degrees, sound travels.....	1147 feet.

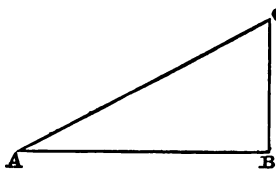
$1147 \times 7 = 8029$ feet, or 2676 yards.

Distances measured by sound should be as long as possible, and if guns are fired from only one end, the distance should be measured on a calm day, or when there is not much wind, as sound is accelerated or retarded by wind. The gun fired should have extreme elevation given to it; and, if possible, guns should be fired from each end of the required distance.

The best method of measuring distance by sound is first to ascertain the number of times that the watch to be used beats in a minute of time. Most pocket chronometers beat five times in two seconds, or 150 beats to a minute; common watches vary. The number of beats of the watch ascertained, it is easy to find the number of yards that sound travels in that beat, making due allowance for the temperature. At 60° Fahr., for instance, sound travels 150 yards in one beat of a chronometer beating 150 times in one minute. That number of yards multiplied by the number of beats observed will give the distance required.

A simple method of counting the beats is by binding the watch close to the ear by means of a pocket handkerchief; this leaves hands and eye free to use glass and note-book. The observer, comfortably placed with his eye on the ship or fort, begins to count on seeing the *flash*, finishing with the *report* of the gun.

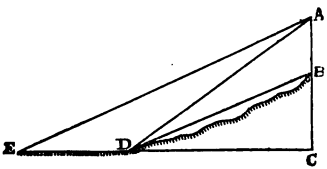
Measuring Heights.



To find the height of a perpendicular object, CB, the base of which is accessible, and on the same level as the observer.

Measure the angle BAC, and distance AB, then;—

$$CB = \text{tan. BAC} \times AB.$$



To find the height of an inaccessible tower, AB, and the difference of level between B and D, the nearest accessible point to BA.

Erect a stake the height of the eye at D, and at E, on the same level as D, observe the angles of elevation AEC and ADC, and measure the base ED:—

$$AC = \frac{ED}{\text{cotan. AED} - \text{cotan. ADC}}.$$ Or by logs.: AC = ED . sin. ADC . sin. AED . cosec. EAD. The height BC can be ascertained in the same way, which subtracted from AC, gives AB.

To find the height, from the angle of elevation or depression to an object, the distance being known.

$$\text{Height} = \frac{\text{Minutes and decimals in angle} \times \text{fathoms in distance}}{573}.$$

To be used for short distances only, otherwise see table at page 262.

Measuring Heights (roughly).

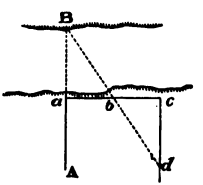
If the object be accessible, measure the length of its shadow, and at the same time the shadow of a pole of known length (or your own shadow): the lengths of the shadows are proportional to the heights. This must be quickly done, as the sun is always on the move.

Or,—Recede from an artificial horizon until the reflected image of the *summit is seen* in the artificial horizon.

Measure the distances between this position and the artificial horizon, also between the artificial horizon and the foot of the object. The distances are in proportion to the height of the observer's eye and the height of the object.

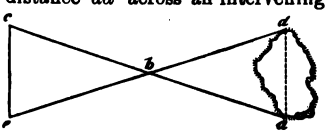
Measuring Distances on Shore.

To continue the measurement of the base line AB, or to measure the distance across an intervening river, etc.



Set off two equal lengths in the same straight line at any convenient angle from *a* to *b* and from *b* to *c*, marking *b* and *c* with pickets; measure from *c* on a line *parallel* * to AB the distance *cd*, between *c* and a point *d*, where the picket at *b* came in line with the object B. The length *cd* will be equal to the required distance *a*B.

Suppose it is required to ascertain the distance *ad* across an intervening pit or pond.



Measure a straight line from *a* to c, and also from *d* to *e*, making $cb = ba$ and $be = bd$, then by equal triangles *ec* is equal to *ad*.

Whence by measuring *ec* we get the required distance *ad*.

Extemporary Measurements.

It is at all times well to know the length of the different joints of the limbs.

Suppose the nail-joint of the forefinger to be one inch, the next joint will be 1¼ inches, the next 2 inches, and from the knuckle to the wrist 4 inches; in this case the finger is bent, so that each joint may be measured separately, though, when held straight, the distance from the tip of the forefinger to the wrist would be only 7 inches. The span with thumb and fore-

* This may be done by pocket sextant or compass.

finger would be 8 inches, and with the thumb and any of the other three, 9 inches, or equal to the length of the foot; from the wrist to the elbow would be 10 inches, and from elbow to the tip of the forefinger 17 inches, and from collar-bone to forefinger 2 feet 8 inches; height to the middle of the knee-cap, 18 inches. From the elbow to the forefinger is usually called a cubit, but it is seldom strictly so, an English cubit being generally stated as 18 inches.

In like manner, the full stretch of the extended arms is called a fathom; but it is generally somewhat less. If a man stands with his back to a flat wall, and extends his arms, his fathom will be scarcely equal to his own height; but if he tries to measure the girth of a tree, by placing his breast against, and as it were embracing it, he will find his fathom many inches short, and on an average, perhaps, not more than 5 feet.

The pulse, when in health, and not excited, beats 72 to 75 times in a minute.

The pace is commonly supposed to be $2\frac{1}{2}$ feet; but this is a most uncertain mode of measurement: very few men, without practice, can take correctly a hundred consecutive steps or paces of the same length. Practice will determine the amount of ground covered in a certain number of paces, if tried over known distances: it, of course, varies, but from experiment, the mean has been found nearly as follows:—

Pacing, at 30 inches per pace, of 108 in a minute, equals 270 feet, or 3·068 statute, or 2·66 nautical miles per hour.

Pacing quickly, at 30 inches per pace, or 120 in a minute, equals 300 feet, or 3·41 statute, or 2·96 nautical miles per hour.

Pacing slowly, at 36 inches, may average 60 per minute, equals 180 feet, or 2·04 statute, or 1·78 nautical miles per hour.

The speed of track horses, on the sides of a canal, may be assumed to be about 3 miles per hour: that of a fair walking horse, to be from $4\frac{1}{2}$ to 5 miles per hour.

The ordinary pace of bullocks is from 2 to $2\frac{1}{2}$ miles an hour. They must not be hurried.

Camels pace at about 2 miles an hour, and keep it up steadily for the longest marches. They will not be hurried.

Elephants pace from 3 to $3\frac{1}{2}$ miles an hour; when laden, can keep up well with infantry in their daily marches.

TABLE OF DISTANCES.

By ALAN STEVENSON.

Table of Distances at which Objects can be seen at Sea, according to their respective Elevations and the Elevation of the Eye of the Observer.

Heights in feet.	Distances in statute or English miles.	Distances in geographical or nautical miles.	Heights in feet.	Distances in statute or English miles.	Distances in geographical or nautical miles.	Heights in feet.	Distances in statute or English miles.	Distances in geographical or nautical miles.
5	2·958	2·565	70	11·067	9·598	250	20·916	18·14
10	4·184	3·628	75	11·456	9·935	300	22·912	19·87
15	5·123	4·443	80	11·832	10·26	350	24·748	21·46
20	5·916	5·130	85	12·196	10·57	400	26·457	22·94
25	6·614	5·736	90	12·549	10·88	450	28·062	24·33
30	7·245	6·283	95	12·893	11·18	500	29·580	25·65
35	7·826	6·787	100	13·228	11·47	550	31·024	26·90
40	8·366	7·255	110	13·874	12·03	600	32·403	28·10
45	8·874	7·696	120	14·490	12·56	650	33·726	29·25
50	9·354	8·112	130	15·083	13·08	700	35·000	30·28
55	9·811	8·509	140	15·652	13·57	800	37·416	32·45
60	10·246	8·886	150	16·201	14·22	900	39·836	34·54
65	10·665	9·249	200	18·708	16·22	1000	41·833	36·28

Example.—A tower, 200 feet high, will be visible to an observer whose eye is elevated 15 feet above the water, 21 nautical miles nearly: thus from the table:—

15 feet elevation, distance visible 4·44 nautical miles.
200 „ „ 16·22 „
20·66

Distance of the Visible Horizon in Nautical Miles.

Allowing for Terrestrial Atmospheric Refraction.

Height.	Distance.	Height.	Distance.	Height.	Distance.	Height.	Distance.	Height.	Distance.
Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.
1	1·15	41	7·35	165	14·75	370	22·09	800	32·59
2	1·62	42	7·44	170	14·97	380	22·39	860	33·79
3	1·99	43	7·53	175	15·19	390	22·68	900	34·56
4	2·30	44	7·62	180	15·41	400	22·97	960	35·69
5	2·57	45	7·70	185	15·62	410	23·26	1000	36·43
6	2·81	46	7·79	190	15·83	420	23·54	1100	38·21
7	3·04	47	7·87	195	16·04	430	23·82	1200	39·91
8	3·25	48	7·96	200	16·24	440	24·09	1300	41·53
9	3·45	49	8·04	205	16·44	450	24·36	1400	43·10
10	3·63	50	8·12	210	16·64	460	24·63	1500	44·62
11	3.81	51	8·20	215	16·84	470	24·90	1600	46·08
12	3·98	52	8·29	220	17·03	480	25·16	1700	47·50
13	4·14	53	8·36	225	17·20	490	25·42	1800	48·88
14	4·30	54	8·44	230	17·42	500	25·68	1900	50·21
15	4·45	55	8·52	235	17·61	510	25·94	2000	51·52
16	4·59	56	8·60	240	17·79	520	26·19	2100	52·79
17	4·74	57	8·67	245	17·98	530	26·44	2200	54·04
18	4·87	58	8·75	250	18·16	540	26·69	2300	55·25
19	5·01	59	8·82	255	18·34	550	26·93	2400	56·44
20	5·14	60	8·90	260	18·52	560	27·18	2500	57·60
21	5·26	65	9·26	265	18·70	570	27·42	2600	58·74
22	5·39	70	9·61	270	18·87	580	27·66	2700	59·86
23	5·51	75	10·05	275	19·05	590	27·90	2800	60·96
24	5·63	80	10·27	280	19·22	600	28·13	2900	62·03
25	5·74	85	10·59	285	19·39	610	28·37	3000	63·10
26	5·86	90	10·90	290	19·56	620	28·60	3250	65·67
27	5·97	95	11·19	295	19 73	630	28·83	3500	68·15
28	6·08	100	11·49	300	19·89	640	29·06	3750	70·55
29	6·19	105	11·77	305	20·06	650	29·28	4000	72·86
30	6·29	110	12·05	310	20·22	660	29·51	4250	75·10
31	6·40	115	12·32	315	20·38	670	29·73	4500	77·28
32	6·50	120	12·58	320	20·55	680	29·95	4750	79·41
33	6·60	125	12·84	325	20·71	690	30·17	5000	81·47
34	6·70	130	13·10	330	20·85	700	30·39	5250	83·48
35	6·80	135	13·35	335	21·02	710	30·60	5500	85·44
36	6·89	140	13·61	340	21·18	720	30·82	5750	87·36
37	6·99	145	13·83	345	21·33	730	31·03	6080	89·83
38	7·08	150	14·06	350	21·49	740	31·24	12,160	126·92
39	*7·17*	155	14·30	355	21·64	750	31·45	18,240	155·61
40	*7·26*	160	14·53	360	21·79	760	31·66	24,320	180·80

To find the Distance of an Object by Two Bearings, and the Distance run between them.

RULE.—Under the number of points contained between the course and second bearing, and opposite to the difference between the course and first bearing, will be found a number, which multiplied by the miles made good, will give the distance of the object (in miles) at the time the last bearing was taken.

N.B.—Due allowance should be made for current.

Difference between the Course and Second Bearing in Points of the Compass.

4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	12½	Pts.	Difference between the Course and First Bearing in points of the Compass.
1·00	0·81 1·23	0·69 1·00	0·60 0·35	0·54 0·74	0·49 0·67	0·46 0·61	0·43 0·57	0·41 0·53	0·40 0·51	0·39 0·49	0·38 0·48	0·38 0·47	0·38 0·47	0·39 0·47	0·40 0·48	0·41 0·49	0·43 0·51	2 2½	
		1·45	1·17 1·66	1·00 1·35	0·88 1·14	0·79 1·00	0·72 0·90	0·67 0·82	0·63 0·76	0·60 0·72	0·58 0·69	0·57 0·66	0·56 0·65	0·56 0·64	0·56 0·64	0·57 0·64	0·58 0·65	3 3½	
				1·85	1·50 2·02	1·27 1·64	1·11 1·39	1·00 1·22	0·92 1·09	0·15 1·00	0·80 0·93	0·76 0·88	0·74 0·84	0·72 0·81	0·71 0·79	0·71 0·78	0·71 0·78	4 4½	
						2·17	1·77 2·30	1·50 1·87	1·31 1·58	1·18 1·39	1·08 1·25	1·00 1·14	0·94 1·06	0·90 1·00	0·87 0·95	0·85 0·92	0·83 0·90	5 5½	
								2·41	1·96 2·50	1·66 2·03	1·46 1·72	1·31 1·51	1·19 1·35	1·11 1·24	1·05 1·15	1·00 1·08	0·97 1·03	6 6½	
										2·56	2·08 2·60	1·76 2·11	1·55 1·79	1·39 1·57	1·27 1·41	1·18 1·29	1·11 1·20	7 7½	
												2·61	2·12 2·60	1·80 2·11	1·58 1·79	1·41 1·57	1·29 1·41	8 8½	
														2·56	2·08 2·50	1·76 2·03	1·55 1·72	9 9½	
																2·41	1·96 2·30	10 10½	

Example.—A rock bore N.N.W.; after running W. 12 miles, it bore N.E. by N. Required the distance of the ship from the rock when the second bearing was taken. The number of points between W. and N.E. by N. is 11: between W. and N.N.W. is 6. Under 11 at the top and opposite 6 at the side, stands 1·11, which multiplied by 12 gives 13·32 miles, the distance of the rock when the second bearing was taken.

APPARENT DIP OF THE HORIZON.

Approximately, the Dip in Minutes is the square root of the Height in Feet.

Height.	Dip.	Height.	Dip.	Height.	Dip.
Feet.	′ ″	Feet.	′ ″	Feet.	′ ″
1	0 58	13	3 27	25	4 52
2	1 21	14	3 36	28	5 5
3	1 40	15	3 42	30	5 15
4	1 56	16	3 50	35	5 39
5	2 9	17	3 57	40	6 4
6	2 21	18	4 4	45	6 27
7	2 33	19	4 11	50	6 46
8	2 44	20	4 17	60	7 25
9	2 53	21	4 23	70	8 1
10	3 2	22	4 30	80	8 34
11	3 10	23	4 36	90	9 6
12	3 19	24	4 42	100	9 35

To find the height when the distance is known: To the constant log. 3·7840 add the log. of the distance in miles and the log. tan. of the corrected altitude. The nat. number of the sum of these logs being added to the number from the following table will give the height in feet.

Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.
1	0·9	11	107	21	390	31	850	41	1487	55	2677
2	3·5	12	127	22	428	32	906	42	1561	60	3186
3	8·0	13	149	23	468	33	964	43	1636	65	3740
4	14·1	14	173	24	510	34	1023	44	1713	70	4337
5	22·1	15	199	25	553	35	1084	45	1792	75	4976
6	31·8	16	226	26	598	36	1147	46	1872	80	5665
7	43·3	17	256	27	645	37	1211	47	1954	85	6394
8	56·6	18	287	28	694	38	1278	48	2039	90	7172
9	71·6	19	319	29	745	39	1346	49	2124	95	7987
10	88·4	20	354	30	797	40	1416	50	2212	100	8852

The table is to be entered with distance of the observer, in miles.

Example.—The altitude of a summit is (corrected for dip) 2° 48′, the distance 20 miles, the height of the eye 16 feet.

20 log.	... ...	1·3010	Height above level of observer 5949
Const.	... ...	3·7840	Cor. for curvature at 20 miles 354
Log. tan.	... ...	8·6894	Height of observer's eye ... 16
5949	... ...	log. 3·7744	Height required in feet ... 6319

Measuring Heights by Barometer.

In this Table the difference between the number of feet opposite the height of a barometer at one station, and that at another, is the approximate difference in the height of the stations.

Barometer in inches.	Height in feet.	Barometer in inches.	Height in feet.	Barometer in inches.	Height in feet.	Barometer in inches.	Height in feet.
31·0	0	27·8	2864	24·6	6083	21·4	9755
30·9	85	27·7	2959	24·5	6190	21·3	9878
30·8	170	27·6	3054	24·4	6297	21·2	10002
30·7	255	27·5	3149	24·3	6405	21·1	10127
30·6	341	27·4	3245	24·2	6514	21·0	10253
30·5	427	27·3	3341	24·1	6623	20·9	10379
30·4	513	27·2	3438	24·0	6733	20·8	10506
30·3	600	27·1	3535	23·9	6843	20·7	10633
30·2	687	27·0	3633	23·8	6953	20·6	10760
30·1	774	26·9	3731	23·7	7064	20·5	10889
30·0	862	26·8	3829	23·6	7175	20·4	11018
29·9	950	26·7	3927	23·5	7287	20·3	11148
29·8	1038	26·6	4025	23·4	7399	20·2	11278
29·7	1126	26·5	4124	23·3	7512	20·1	11409
29·6	1215	26·4	4223	23·2	7625	20·0	11541
29·5	1304	26·3	4323	23·1	7729	19·9	11673
29·4	1393	26·2	4423	23·0	7854	19·8	11805
29·3	1482	26·1	4524	22·9	7969	19·7	11939
29·2	1572	26·0	4625	22·8	8085	19·6	12074
29·1	1662	25·9	4726	22·7	8201	19·5	12210
29·0	1753	25·8	4828	22·6	8317	19·4	12346
28·9	1844	25·7	4930	22·5	8434	19·3	12483
28·8	1935	25·6	5033	22·4	8551	19·2	12620
28·7	2027	25·5	5136	22·3	8669	19·1	12757
28·6	2119	25·4	5240	22·2	8787	19·0	12894
28·5	2211	25·3	5344	22·1	8906	18·9	12948
28·4	2303	25·2	5448	22·0	9025	18·8	13080
28·3	2396	25·1	5553	21·9	9145	18·7	13219
28·2	2489	25·0	5658	21·8	9266	—	—
28·1	2582	24·9	5763	21·7	9388	—	—
28·0	2675	24·8	5869	21·6	9510	—	—
27·9	2769	24·7	5976	21·5	9632	—	—

If possible, simultaneous observations, by signal or time, of two barometers previously compared at the same station, should be taken. But little dependence can be placed on observations beyond 4000 feet, when made with the Aneroid.

Table for converting Admiralty Knots into Statute Miles.

(The Admiralty Knot = 6080 feet.* The Statute Mile = 5280 feet.

Admiralty Knots.	Statute Miles.	Admiralty Knots.	Statute Miles.	Admiralty Knots.	Statute Miles.	Admiralty Knots.	Statute Miles.
1·00	1·151	7·25	8·348	13·50	15·545	19·75	22·742
1·25	1·439	7·50	8·636	13·75	15·833	20·00	23·030
1·50	1·729	7·75	8·924	14·00	16·121	20·25	23·318
1·75	2·015	8·00	9·212	14·25	16·409	20·50	23·606
2·00	2·303	8·25	9·500	14·50	16·696	20·75	23·893
2·25	2·590	8·50	9·787	14·75	16·984	21·00	24·181
2·50	2·878	8·75	10·075	15·00	17·272	21·25	24·469
2·75	3·166	9·00	10·393	15·25	17·560	21·50	24·757
3·00	3·454	9·25	10·615	15·50	17·848	21·75	25·045
3·25	3·742	9·50	10·939	15·75	18·136	22·00	25·333
3·50	4·030	9·75	11·227	16·00	18·424	22·25	25·621
3·75	4·318	10·00	11·515	16·25	18·712	22·50	25·909
4·00	4·606	10·25	11·803	16·50	18·999	22·75	26·196
4·25	4·893	10·50	12·090	16·75	19·287	23·00	26·484
4·50	5·181	10·75	12·378	17·00	19·575	23·25	26·772
4·75	5·469	11·00	12·666	17·25	19·863	23·50	27·060
5·00	5·757	11·25	12·954	17·50	20·151	23·75	27·348
5·25	6·045	11·50	13·242	17·75	20·439	24·00	27·636
5·50	6·333	11·75	13·530	18·00	20·727	24·25	27·924
5·75	6·621	12·00	13·818	18·25	21·015	24·50	28·212
6·00	6·909	12·25	14·106	18·50	21·303	24·75	28·499
6·25	7·196	12·50	14·393	18·75	21·590	25·00	28·787
6·50	7·484	12·75	14·681	19·00	21·878	—	—
6·75	7·772	13·00	14·969	19·25	22·166	—	—
7·00	8·060	13·25	15·257	19·50	22·454	—	—

* The Geographical Mile is generally defined to be the length of a minute of arc in the earth's equator; but the Nautical Mile as defined by hydrographers is the length of a minute of the meridian, and is different for every different latitude. (*See* Carrington's Table, page 180.) It is equal to a minute of arc in a circle, whose radius is the radius of the curvature of the meridian, at the latitude of the place.

Table for converting Statute Miles into Admiralty Knots.

(The Statute Mile = 5280 feet. The Admiralty Knot = 6080 feet.*)

Statute Miles.	Admiralty Knots.	Statute Miles.	Admiralty Knots.	Statute Miles.	Admiralty Knots.	Statute Miles.	Admiralty Knots.
1·00	0·868	8·25	7·164	15·50	13·460	22·75	19·756
1·25	1·085	8·50	7·381	15·75	13·677	23·00	19·973
1·50	1·302	8·75	7·598	16·00	13·894	23·25	20·190
1·75	1·519	9·00	7·815	16·25	14·111	23·50	20·407
2·00	1·736	9·25	7·032	16·50	14·328	23·75	20·625
2·25	1·953	9·50	8·250	16·75	14·546	24·00	20·842
2·50	2·171	9·75	8·867	17·00	14·763	24·25	21·059
2·75	2·388	10·00	8·684	17·25	14·980	24·50	21·276
3·00	2·605	10·25	8·901	17·50	15·197	24·75	21·493
3·25	2·822	10·50	9·118	17·75	15·414	25·00	21·710
3·50	3·039	10·75	9·335	18·00	15·631	25·25	21·927
3·75	3·256	11·00	9·552	18·25	15·848	25·50	22·114
4·00	3·473	11·25	9·769	18·50	16·065	24·75	22·361
4·25	3·690	11·50	9·986	18·75	16·282	26·00	22·578
4·50	3·907	11·75	10·203	19·00	16·500	26·25	22·796
4·75	4·125	12·00	10·421	19·25	16·717	26·50	23·013
5·00	4·342	12·25	10·638	19·50	16·934	26·75	23·230
5·25	4·559	12·50	10·855	19·75	17·151	27·00	23·447
5·50	4·776	12·75	11·072	20·00	17·368	27·25	23·664
5·75	4·993	13·00	11·289	20·25	17·585	27·50	23·881
6·00	5·210	13·25	11·506	20·50	17·802	27·75	24·098
6·25	5·427	13·50	11·723	20·75	18·019	28·00	24·315
6·50	5·644	13·75	11·940	21·00	18·236	28·25	24·532
6·75	5·861	14·00	12·157	21·25	18·453	28·50	24·750
7·00	6·078	14·25	12·375	21·50	18·671	28·75	24·967
7·25	6·296	14·50	12·592	21·75	18·888	29·00	25·184
7·50	6·513	14·75	12·809	22·00	19·105	—	—
7·75	6·730	15·00	13·026	22·25	19·322	—	—
8·00	6·947	15·25	13·243	22·50	19·539	—	—

* The Geographical Mile is generally defined to be the length of a minute of arc in the earth's equator; but the Nautical Mile as defined by hydrographers is the length of a minute of the meridian, and is different for every different latitude. (*See* Carrington's Table, page 180.) It is equal to a minute of arc in a circle, whose radius is the radius of the curvature of the meridian, at the latitude of the place.

TRIAL TRIP TABLE.

The minutes and seconds of time, in which a vessel passes over the measured mile, being known, the corresponding number in this table will be the speed of the vessel in knots.

Sec.	3m.	4m.	5m.	6m.	7m.	8m.	9m.	10m.	11m.	12m.	13m.	14m.
0	20·000	15·000	12·000	10·000	8·571	7·500	6·666	6·000	5·454	5·000	4·615	4·285
1	19·890	14·938	11·960	9·972	8·551	7·484	6·654	5·990	5·446	4·993	4·609	4·280
2	19·780	14·876	11·920	9·944	8·530	7·468	6·642	5·980	5·438	4·986	4·603	4·275
3	19·672	14·815	11·880	9·917	8·510	7·453	6·629	5·970	5·429	4·979	4·597	4·270
4	19·564	14·754	11·841	9·890	8·490	7·438	6·617	5·960	5·421	4·972	4·591	4·265
5	19·460	14·694	11·803	9·863	8·470	7·422	6·605	5·950	5·413	4·965	4·585	4·260
6	19·355	14·634	11·764	9·830	8·450	7·407	6·593	5·940	5·405	4·958	4·580	4·265
7	19·251	14·575	11·726	9·809	8·430	7·392	6·581	5·930	5·397	4·951	4·574	4·250
8	19·150	14·516	11·688	9·783	8·413	7·377	6·569	5·921	5·389	4·945	4·568	4·245
9	19·047	14·457	11·650	9·756	8·392	7·362	6·557	5·911	5·381	4·938	4·562	4·240
10	18·947	14·400	11·613	9·729	8·372	7·346	6·545	5·901	5·373	4·931	4·556	4·235
11	18·848	14·342	11·575	9·703	8·353	7·331	6·533	5·891	5·365	4·924	4·551	4·230
12	18·750	14·285	11·538	9·677	8·334	7·317	6·521	5·882	5·357	4·918	4·545	4·225
13	18·652	14·220	11·501	9·651	8·315	7·302	6·509	5·872	5·349	4·911	4·539	4·220
14	18·556	14·173	11·465	9·625	8·293	7·287	6·498	5·863	5·341	4·904	4·534	4·215
15	18·461	14·118	11·428	9·600	8·276	7·272	6·486	5·853	5·333	4·897	4·528	4·210
16	18·367	14·063	11·392	9·574	8·257	7·258	6·474	5·844	5·325	4·891	4·522	4·206
17	18·274	14·008	11·356	9·549	8·228	7·243	6·463	5·834	5·317	4·884	4·516	4·201
18	18·181	13·953	11·323	9·524	8·219	7·229	6·451	5·825	5·309	4·878	4·511	4·196
19	18·090	13·900	11·285	9·490	8·200	7·214	6·440	5·815	5·301	4·871	4·505	4·191
20	18·000	13·846	11·250	9·473	8·181	7·200	6·428	5·806	5·294	4·864	4·500	4·186
21	17·910	13·793	11·214	9·448	8·163	7·185	6·417	6·797	5·286	4·858	4·494	4·181
22	17·823	13·740	11·180	9·424	8·144	7·171	6·405	6·787	5·278	4·851	4·488	4·176
23	17·734	13·688	11·146	9·399	8·127	7·157	6·394	5·778	5·270	4·845	4·483	4·171
24	17·647	13·636	11·111	9·375	8·108	7·142	6·383	5·769	5·263	4·838	4·477	4·166
25	17·560	13·584	11·077	9·350	8·090	7·128	6·371	5·760	5·255	4·832	4·472	4·161
26	17·475	13·533	11·043	9·326	8·071	7·114	6·360	5·750	5·247	4·825	4·466	4·157
27	17·391	13·483	11·009	9·302	8·053	7·100	6·349	5·741	5·240	4·819	4·460	4·152
28	17·307	13·432	11·975	9·278	8·035	7·086	6·388	5·732	5·232	4·812	4·455	4·147
29	17·225	13·383	10·942	9·254	8·017	7·072	6·327	5·723	5·224	4·806	4·449	4·142

Trial Trip Table—(*continued*).

Sec.	3m.	4m.	5m.	6m.	7m.	8m.	9m.	10m.	11m.	12m.	13m.	14m.
30	17·143	13·333	10·909	9·230	8·000	7·059	6·315	5·714	5·217	4·800	4·444	4·137
31	17·061	13·284	10·876	9·207	7·982	7·045	6·304	5·705	5·210	4·793	4·438	4·133
32	16·981	13·235	10·843	9·183	7·964	7·031	6·293	5·696	5·202	4·787	4·433	4·128
33	16·901	13·186	10·810	9·160	7·947	7·017	6·282	5·687	5·195	4·780	4·428	4·123
34	16·822	13·138	10·778	9·137	7·929	7·004	6·271	5·678	5·187	4·774	4·422	4·118
35	16·744	13·092	10·744	9·113	7·912	6·990	6·260	5·669	5·179	4·769	4·417	4·114
36	16·667	13·043	10·714	9·090	7·825	6·977	6·250	5·660	5·172	4·761	4·411	4·110
37	16·590	12·926	10·682	9·068	7·877	6·963	6·239	5·651	5·164	4·755	4·406	4·105
38	16·514	12·950	10·651	9·044	7·860	6·950	6·228	5·642	5·157	4·749	4·400	4·100
39	16·438	12·903	10·619	9·022	7·843	6·936	6·217	5·633	5·150	4·743	4·395	4·095
40	16·363	12·857	10·588	9·000	7·826	6·923	6·207	5·625	5·142	4·738	4·390	4·090
41	16·289	12·811	10·557	8·977	7·809	6·909	6·196	5·616	5·135	4·730	4·384	4·085
42	16·216	12·766	10·526	8·955	7·792	6·896	6·185	5·607	5·128	4·724	4·379	4·081
43	16·143	12·711	10·495	8·933	7·775	6·883	6·174	5·598	5·121	4·718	4·374	4·077
44	16·071	12·676	10·465	8·911	7·758	6·870	6·164	5·590	5·114	4·712	4·368	4·072
45	16·000	12·631	10·434	8·889	7·741	6·857	6·153	5·581	5·106	4·706	4·363	4·067
46	15·929	12·587	10·404	8·867	7·725	6·844	6·143	5·572	5·099	4·700	4·358	4·063
47	15·859	12·543	10·375	8·845	7·708	6·831	6·132	5·564	5·091	4·693	4·353	4·058
48	15·789	12·500	10·345	8·823	7·692	6·818	6·122	5·555	5·084	4·687	4·347	4·054
49	15·721	12·456	10·315	8·801	7·675	6·805	6·112	5·547	5·077	4·681	4·342	4·049
50	15·652	12·413	10·286	8·780	7·659	6·792	6·101	5·538	5·070	4·675	4·337	4·044
51	15·584	12·371	10·256	8·759	7·643	6·779	6·091	5·530	5·063	4·669	4·332	4·040
52	15·517	12·329	10·227	8·737	7·627	6·766	6·081	5·521	5·056	4·663	4·326	4·035
53	15·450	12·287	10·198	8·716	7·611	6·754	6·071	5·513	5·049	4·657	4·321	4·031
54	15·384	12·245	10·169	8·695	7·595	6·741	6·060	5·504	5·042	4·651	4·316	4·026
55	15·319	12·203	10·140	8·675	7·579	6·739	6·050	5·496	5·035	4·645	4·311	4·022
56	15·254	12·162	10·112	8·654	7·563	6·716	6·040	5·487	5·028	4·639	4·306	4·017
57	15·190	12·121	10·084	8·633	7·547	6·704	6·030	5·479	5·020	4·633	4·301	4·013
58	15·125	12·080	10·055	8·612	7·531	6·691	6·020	5·471	5·013	4·627	4·295	4·008
59	15·062	12·040	10·027	8·591	7·515	6·679	6·010	5·463	5·006	4·621	4·290	4·004

Table for ascertaining Velocity of Tide by noting the number of Seconds a Knot of 47·3 feet, measured on the Log Line, takes to run out.

Time in Seconds.	Rate in Knots.	Time in Seconds.	Rate in Knots.	Time in Seconds.	Rate in Knots.	Time in Seconds.	Rate in Knots.
5	5·76	17	1·65	29	0·96	41	0·68
6	4·80	18	1·55	30	0·93	42	0·67
7	3·99	19	1·47	31	0·90	43	0·65
8	3·50	20	1·40	32	0·87	44	0·63
9	3·20	21	1·33	33	0·85	45	0·62
10	2·80	22	1·27	34	0·82	46	0·61
11	2·54	23	1·23	35	0·80	47	0·60
12	2·23	24	1·17	36	0·78	48	0·58
13	2·15	25	1·12	37	0·76	49	0·57
14	1·99	26	1·08	38	0·74	—	—
15	1·87	27	1·04	39	0·72	—	—
16	1·76	28	1·00	40	0·70	—	—

NOTE.—Three or four knots should be timed, and the mean taken.

Clark-Russell's Log will also be found useful for ascertaining the velocity of the tide.

Table showing the Number of Feet subtending an Angle of 1′ at given distances to 32 Nautical Miles.

One foot subtends an angle of 1′ at a distance of 3437·75 feet.

Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.
1	1·77	9	15·92	17	30·07	25	44·23
2	3·54	10	17·69	18	31·84	26	46·00
3	5·31	11	19·46	19	33·61	27	47·76
4	7·08	12	21·23	20	35·38	28	49·53
5	8·84	13	23·00	21	37·15	29	51·30
6	10·61	14	24·77	22	38·92	30	53·07
7	12·38	15	26·53	23	40·69	31	54·83
8	14·15	16	28·30	24	42·46	32	56·60

This table shows the error in height which would result from an error of 1′ (and, by multiplication, of any small number of minutes) in the angle of elevation. It also gives, by simple proportion, the height of any object, whose distance from the observer is known, that does not subtend a vertical angle extending 4°; and, *vice versâ*, the distance of any object whose height is known may also be determined.

If length instead of height is required or known, care must be taken that the object used (for instance a ship) lies broadside on to the observer.

The length of an arc = No. of degrees × radius × ·07145.

Table for correcting Longitude by Chronometer for error due to having used an approximate Latitude.

Compiled by LIEUT. J. F. STUART, R.N.

Change of Longitude in miles, due to a change of one mile of Latitude.

LATITUDE.

Azimuth	0	10	15	20	22	24	26	28	29	30	31	32	33	34	35	36	37	38	39
89	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02
88	·03	·03	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04	·04
87	·05	·05	·05	·05	·06	·06	·06	·06	·06	·06	·06	·06	·06	·06	·06	·06	·06	·06	·06
86	·07	·07	·07	·07	·08	·08	·08	·08	·08	·08	·08	·08	·08	·08	·08	·09	·09	·09	·09
85	·09	·09	·09	·09	·09	·09	·10	·10	·10	·10	·10	·10	·10	·10	·10	·11	·11	·11	·11
84	·10	·11	·11	·11	·11	·11	·12	·12	·12	·12	·12	·12	·12	·13	·13	·13	·13	·13	·13
83	·12	·12	·13	·13	·13	·13	·14	·14	·14	·14	·14	·14	·15	·15	·15	·15	·15	·16	·16
82	·14	·14	·15	·15	·15	·15	·16	·16	·16	·16	·16	·17	·17	·17	·17	·17	·17	·18	·18
81	·16	·16	·16	·17	·17	·17	·17	·18	·18	·19	·19	·19	·19	·19	·19	·20	·20	·20	·20
80	·18	·18	·18	·19	·19	·19	·19	·20	·20	·21	·21	·21	·21	·21	·21	·22	·22	·22	·22
79	·19	·20	·20	·21	·21	·21	·21	·22	·22	·23	·23	·23	·23	·23	·24	·24	·24	·24	·25
78	·21	·22	·22	·23	·23	·23	·23	·24	·24	·25	·25	·25	·25	·26	·26	·26	·27	·27	·27
77	·23	·24	·24	·25	·25	·25	·26	·26	·26	·27	·27	·27	·28	·28	·28	·29	·29	·29	·30
76	·25	·25	·26	·27	·27	·27	·28	·28	·28	·29	·29	·29	·30	·30	·30	·31	·31	·31	·32
75	·27	·27	·28	·29	·29	·29	·30	·30	·30	·31	·31	·31	·32	·32	·33	·33	·33	·34	·34
74	·29	·29	·30	·31	·31	·31	·32	·32	·33	·33	·33	·33	·34	·34	·35	·35	·36	·36	·37
73	·31	·31	·32	·33	·33	·33	·34	·35	·35	·35	·36	·36	·36	·37	·37	·38	·38	·39	·40
72	·32	·33	·34	·35	·35	·36	·36	·37	·37	·38	·38	·38	·39	·39	·40	·40	·41	·41	·42
71	·34	·35	·36	·37	·37	·38	·38	·39	·39	·40	·40	·40	·41	·41	·42	·42	·43	·43	·44
70	·36	·37	·38	·39	·39	·40	·40	·41	·41	·42	·42	·43	·43	·43	·44	·45	·45	·46	·47
69	·38	·39	·40	·41	·41	·42	·43	·43	·44	·45	·45	·45	·46	·46	·47	·47	·48	·49	·50
68	·40	·41	·42	·43	·44	·44	·45	·46	·46	·47	·47	·48	·48	·49	·49	·50	·50	·51	·52
67	·42	·43	·44	·45	·46	·46	·47	·48	·48	·49	·50	·50	·50	·51	·52	·52	·53	·54	·55
66	·44	·45	·46	·47	·48	·49	·49	·50	·51	·52	·52	·52	·53	·54	·54	·55	·56	·56	·57
65	·47	·47	·48	·49	·50	·51	·52	·53	·53	·54	·54	·55	·55	·56	·57	·58	·58	·59	·60
64	·49	·49	·50	·52	·52	·53	·54	·55	·55	·56	·57	·57	·58	·59	·60	·60	·61	·62	·63
63	·51	·51	·52	·54	·55	·56	·56	·57	·58	·59	·59	·60	·61	·61	·62	·63	·64	·65	·66
62	·53	·54	·55	·57	·57	·58	·59	·60	·61	·62	·62	·63	·63	·64	·65	·66	·67	·68	·69
61	·55	·56	·57	·59	·60	·61	·62	·63	·63	·64	·64	·65	·66	·67	·68	·68	·69	·70	·71
60	·58	·58	·59	·61	·62	·63	·64	·65	·66	·67	·67	·68	·69	·70	·70	·71	·72	·73	·74
59	·60	·61	·62	·64	·65	·66	·67	·68	·69	·69	·70	·71	·72	·73	·73	·74	·75	·76	·77
58	·62	·63	·65	·66	·67	·68	·70	·71	·71	·72	·73	·74	·75	·75	·76	·77	·78	·79	·80
57	·65	·66	·67	·69	·70	·71	·72	·74	·74	·75	·76	·77	·78	·78	·79	·80	·81	·82	·84
56	·67	·68	·70	·72	·73	·74	·75	·76	·77	·78	·79	·80	·80	·81	·82	·83	·84	·85	·87
55	·70	·71	·72	·74	·75	·77	·78	·79	·80	·81	·81	·83	·83	·84	·85	·86	·88	·89	·90
54	·73	·74	·75	·77	·78	·80	·81	·82	·83	·84	·84	·86	·87	·88	·89	·90	·91	·92	·93
53	·75	·77	·78	·80	·81	·83	·84	·85	·86	·87	·87	·89	·90	·91	·92	·93	·94	·96	·97
52	·78	·79	·81	·83	·84	·85	·87	·88	·89	·90	·91	·92	·93	·94	·95	·96	·98	·99	1·01
51	·81	·82	·84	·86	·87	·89	·90	·92	·93	·94	·95	·96	·97	·98	·99	1·00	1·01	1·03	1·04
50	·84	·85	·87	·89	·90	·92	·93	·95	·96	·97	·98	·99	1·00	1·01	1·02	1·04	1·05	1·06	1·08
49	·87	·88	·90	·92	·94	·95	·97	·98	·99	1·00	1·01	1·02	1·04	1·05	1·06	1·07	1·09	1·10	1·12
48	·90	·91	·93	·96	·97	·99	1·00	1·02	1·03	1·04	1·05	1·06	1·07	1·08	1·10	1·11	1·13	1·14	1·16
47	·93	·95	·96	·99	1·01	1·02	1·04	1·06	1·07	1·08	1·09	1·10	1·11	1·12	1·14	1·15	1·17	1·18	1·20
46	·97	·98	1·00	1·03	1·04	1·06	1·07	1·09	1·10	1·12	1·13	1·14	1·15	1·16	1·18	1·19	1·21	1·23	1·24
45	1·00	1·02	1·04	1·06	1·08	1·10	1·11	1·13	1·14	1·15	1·17	1·18	1·19	1·21	1·22	1·24	1·25	1·27	1·29

Table for correcting Longitude—(*continued*).

Change of Longitude in miles, due to a change of one mile of Latitude.

LATITUDE.

Azimuth	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
89	·02	·02	·02	·02	·02	·02	·03	·03	·03	·03	·03	·03	·03	·03	·03	·03	·03	·03	·03	·03	·03
88	·04	·04	·05	·05	·05	·05	·05	·05	·05	·05	·05	·06	·06	·06	·06	·06	·06	·06	·07	·07	·07
87	·06	·06	·07	·07	·07	·07	·08	·08	·08	·08	·08	·08	·09	·09	·09	·09	·09	·10	·10	·10	·10
86	·09	·09	·09	·09	·10	·10	·10	·10	·10	·10	·11	·11	·11	·11	·12	·12	·12	·13	·13	·13	·14
85	·11	·11	·12	·12	·12	·13	·13	·13	·13	·14	·14	·14	·14	·15	·15	·16	·16	·16	·17	·17	·17
84	·14	·14	·14	·14	·15	·15	·15	·16	·16	·16	·17	·17	·18	·18	·18	·19	·19	·20	·20	·21	·21
83	·16	·16	·16	·17	·17	·17	·18	·18	·18	·19	·19	·20	·20	·21	·21	·22	·22	·23	·23	·24	·25
82	·18	·19	·19	·19	·20	·20	·20	·21	·21	·22	·22	·23	·23	·24	·24	·25	·25	·26	·27	·27	·28
81	·21	·21	·21	·22	·22	·22	·23	·23	·24	·24	·25	·25	·26	·26	·27	·28	·28	·29	·30	·31	·32
80	·23	·23	·24	·24	·24	·25	·25	·26	·26	·27	·27	·28	·29	·29	·30	·31	·31	·32	·33	·34	·35
79	·25	·26	·26	·26	·27	·27	·28	·28	·29	·30	·30	·31	·32	·32	·33	·34	·35	·36	·37	·38	·39
78	·27	·28	·28	·29	·29	·30	·31	·31	·32	·32	·33	·34	·35	·35	·36	·37	·38	·39	·40	·41	·42
77	·30	·30	·31	·31	·32	·33	·33	·34	·35	·35	·36	·37	·38	·39	·39	·40	·41	·43	·44	·45	·46
76	·32	·33	·33	·34	·34	·35	·36	·37	·37	·38	·39	·40	·41	·41	·42	·44	·45	·46	·47	·49	·50
75	·35	·35	·36	·36	·37	·37	·38	·39	·40	·41	·42	·43	·44	·44	·45	·47	·48	·49	·51	·52	·54
74	·37	·38	·38	·39	·40	·40	·41	·42	·43	·44	·45	·46	·47	·48	·49	·50	·51	·53	·54	·56	·57
73	·40	·40	·41	·42	·42	·43	·44	·45	·46	·47	·48	·49	·50	·51	·52	·53	·55	·56	·58	·60	·61
72	·42	·43	·44	·44	·45	·46	·47	·48	·49	·50	·51	·52	·53	·54	·55	·57	·58	·60	·61	·63	·65
71	·45	·45	·46	·47	·48	·49	·50	·52	·52	·53	·54	·55	·56	·57	·59	·60	·62	·63	·65	·67	·69
70	·47	·48	·49	·50	·51	·52	·52	·54	·55	·56	·57	·58	·59	·61	·62	·64	·65	·67	·69	·71	·73
69	·50	·51	·52	·52	·53	·54	·55	·56	·57	·59	·60	·61	·62	·64	·66	·67	·69	·70	·72	·75	·77
68	·53	·53	·54	·55	·56	·57	·58	·59	·60	·62	·63	·64	·66	·67	·69	·71	·72	·74	·76	·78	·81
67	·55	·56	·57	·58	·59	·60	·61	·62	·63	·65	·66	·67	·69	·71	·72	·74	·76	·78	·80	·82	·85
66	·58	·59	·60	·61	·62	·63	·64	·65	·66	·68	·69	·71	·72	·74	·76	·78	·80	·82	·84	·86	·89
65	·61	·62	·63	·64	·65	·66	·67	·68	·70	·71	·72	·74	·76	·78	·79	·81	·83	·86	·88	·90	·93
64	·64	·65	·66	·67	·68	·69	·70	·71	·73	·74	·76	·77	·79	·81	·83	·85	·87	·89	·92	·95	·98
63	·67	·68	·69	·70	·71	·72	·73	·75	·76	·78	·79	·81	·83	·85	·87	·89	·91	·94	·96	·99	1·02
62	·70	·71	·72	·73	·74	·75	·77	·78	·80	·81	·83	·84	·86	·88	·90	·93	·95	·97	1·00	1·03	1·06
61	·72	·73	·74	·76	·77	·78	·80	·81	·83	·85	·86	·88	·90	·92	·94	·96	·99	1·02	1·05	1·08	1·11
60	·75	·76	·77	·79	·80	·81	·83	·85	·86	·88	·90	·92	·94	·96	·98	1·01	1·03	1·06	1·09	1·12	1·15
59	·79	·80	·81	·82	·83	·85	·87	·89	·90	·92	·94	·96	·98	1·00	1·02	1·05	1·07	1·10	1·13	1·17	1·20
58	·82	·83	·84	·85	·87	·88	·90	·92	·93	·95	·97	·99	1·01	1·04	1·06	1·09	1·12	1·15	1·18	1·21	1·25
57	·85	·86	·87	·89	·90	·92	·94	·95	·97	·99	1·01	1·03	1·05	1·08	1·11	1·13	1·16	1·19	1·23	1·26	1·30
56	·88	·89	·91	·92	·94	·95	·97	·99	1·01	1·03	1·05	1·07	1·09	1·12	1·15	1·17	1·20	1·24	1·27	1·31	1·35
55	·91	·93	·94	·96	·97	·99	1·01	1·03	1·05	1·07	1·09	1·11	1·13	1·16	1·19	1·22	1·25	1·29	1·32	1·36	1·40
54	·95	·96	·98	·99	1·01	1·03	1·05	1·07	1·09	1·11	1·13	1·15	1·18	1·21	1·24	1·27	1·30	1·33	1·37	1·41	1·45
53	·98	1·00	1·01	1·03	1·05	1·07	1·09	1·11	1·13	1·15	1·17	1·20	1·22	1·25	1·28	1·31	1·35	1·38	1·42	1·46	1·51
52	1·02	1·03	1·05	1·07	1·09	1·11	1·12	1·15	1·17	1·19	1·22	1·24	1·27	1·30	1·33	1·36	1·40	1·44	1·47	1·52	1·56
51	1·06	1·07	1·09	1·11	1·13	1·15	1·17	1·19	1·21	1·23	1·26	1·29	1·31	1·35	1·38	1·41	1·45	1·49	1·53	1·57	1·62
50	1·09	1·11	1·13	1·15	1·17	1·19	1·21	1·23	1·25	1·28	1·30	1·33	1·36	1·39	1·43	1·46	1·50	1·54	1·58	1·63	1·68
49	1·13	1·15	1·17	1·19	1·21	1·23	1·25	1·27	1·30	1·32	1·35	1·38	1·41	1·44	1·48	1·51	1·55	1·59	1·64	1·69	1·74
48	1·17	1·19	1·21	1·23	1·25	1·27	1·30	1·32	1·35	1·37	1·40	1·43	1·46	1·49	1·53	1·57	1·61	1·65	1·70	1·75	1·80
47	1·22	1·23	1·25	1·27	1·30	1·32	1·34	1·37	1·39	1·42	1·45	1·48	1·51	1·55	1·59	1·63	1·67	1·71	1·76	1·81	1·86
46	1·26	1·28	1·30	1·32	1·34	1·37	1·39	1·42	1·44	1·47	1·50	1·53	1·57	1·60	1·64	1·68	1·73	1·77	1·82	1·88	1·93
45	1·30	1·32	1·35	1·37	1·39	1·41	1·44	1·47	1·49	1·52	1·56	1·59	1·62	1·66	1·70	1·74	1·79	1·84	1·89	[illegible]	[illegible]

See Notes upon page 272 on use of these tables.

Notes on preceding Table by Lieut. J. F. Stuart, R.N., for correcting Longitude by Chronometer for error due to having used an approximate Latitude.

The change of longitude is East:—

When the true latitude is South of the approximate, and azimuth of object between N. and E., or between S. and W.

When the true latitude is North of the approximate, and azimuth of object between S. and E., or between N. and W.

The change of longitude is West:—

When the true latitude is South of the approximate, and azimuth of object between S. and E., or between N. and W.

When the true latitude is North of the approximate, and azimuth of object between N. and E., or between S. and W.

SECTION VI.

BOATS—WEIGHTS AND DIMENSIONS—GENERAL HINTS ON MANAGEMENT — RIG OF BOATS — REGULATIONS FOR BOAT AND YACHT RACING—DISEMBARKING TROOPS.

Weights and Carrying Capacity of Boats ordinarily in use in Her Majesty's Navy.

Description of Boat.	Length.	Weight, with fittings that cannot be removed, but without boilers		In moderate weather will carry
	Feet.	Cwt.	Qrs.	Men.
Steam Launch	42	113	0	70
„ Pinnace	37	83	0	50
„ Cutter	28	33	0	28
„ „	25	21	0	24
„ „	21	13	0	18
Launch	42	104	0	140
„	38	89	0	109
Pinnace	32	57	0	70
„	30	52	0	62
Admiral's Barge	34	23	0	54
Cutter	32	20	1	59
„	30	18	3	49
„	28	17	2	40
„	25	15	2	34
„	23	14	0	27
„	20	10	0	21
Gig	32	9	1	28
„	30	9	0	26
„	28	8	2	25
„	26	7	3	23
„	25	7	2	22
„	22	6	3	19
Life Whale Boat	28	11	0	25
„	25	8	3	22
„	23	8	1	20
Troop Boat	38	26	0	80
Dingy	14	4	3	10
„	12	3	3	9

First-class torpedo boats range from eighty to ninety feet in length, and weigh from twenty-five to thirty tons.

Second-class torpedo boats are sixty feet long, and their hoisting weight is from eight to nine tons.

Practical Hints for the Consideration and Guidance of Officers having charge of Boats.

*Compiled from various sources.**

Before leaving the ship see that the boat's gear, such as masts, sails, oars, fenders, boat-hooks, baler, anchor and cable, painter, flags, barécas of water, rudder, awning and stanchions, is complete, and that she is properly equipped for the service on which she may be going. Compass and lead line may be required. Spyglass, watch, and sextant, note book and signal book, must be the especial care of the officer in charge. If the boat is to be detached for any length of time, clothes, provisions, and spare gear should also be carefully mustered, and every precaution taken to ensure nothing being left behind.

In shoving off, when the ship is not head to wind, pull well clear of her before making sail. Be very particular about the sails being properly set. Sling a dipping lug one-third from the foremast yard-arm; standing lug one-fourth.

To set a lug sail well; hoist it as *taut up* as you can. You can hardly overdo this, if there is any wind; but do not be too strong with the sheet.

Always keep your boat under command, sufficient sail, well set, and not too much.

To make good progress to windward, constant attention is required to see that you are neither off the wind nor too near. The boat should always be *in the right condition for tacking* when on a wind.

Observe how the wind is. Do not take for granted that the ship you are going alongside is exactly head to wind.

In hauling sheets aft, proportion your strength to the force of the wind. It sometimes occurs that the sheet is dragged aft quite flat in light winds, which spoils the boat's sailing, and the sail. The sail should always have *life* in it.

When coming down before the wind, or free to go alongside, take such a sweep as will enable you to bring her alongside with a small helm and without the main sheet being flat aft. By this means you will have the boat thoroughly under command, which is not the case when obliged to put the

* The additional hints introduced in this edition are by Vice-Admiral de Horsey.

helm *hard* down, for then you *can do no more*, and any little error in estimating your distance will cause you to run into the ship. Besides, putting the helm hard over and flattening the main sheet stops the boat's way and makes her leewardly.

Always come head to wind in going alongside a wharf, and if practicable go the lee side of a wharf. When going alongside before the wind or free is unavoidable, shorten all sail in ample time—after sails first—and have a stern-fast ready.

When deep laden, be more than usually particular to keep way on your boat, so as not to get "in irons."

In loading a boat, keep the ends clear, if necessary piling your cargo higher amidships. Load more by the stern than by the head, but keep the well clear for baling.

Trim a boat, if practicable, so as to carry just *a little* weather helm. For this purpose, with no sitters, you will generally require your men well aft; but do not let the crew sit by your side in the stern sheets. Those abaft the after thwart should sit down in the bottom of the boat.

Under sail, with only your crew, allow no one to remain before the mast.

When it can be avoided, never run with the wind right aft, rather run half the distance with the wind a point on the quarter, and the other half with the wind a point on the other quarter. By this means you will generally go half a knot faster, and run no risk of jibing, whilst the additional distance passed over is inappreciable. With a dipping lug, running with the wind right aft is inadmissible.

Ballast should be stowed near the centre of the boat, and should invariably be secured so as to prevent possibility of shifting. The neglect of this has caused many an accident. None but water ballast and the boat's gear is admissible for men-of-war's boats.

Do not allow men to sit on the gunwale, stand on the thwarts, or climb the mast.

As a general rule, a reef should be taken in directly the boat begins to wet.

Before reefing on a wind tell the men off for the different duties: the two bowmen to gather down on the luff; the weather hands by the halliards and downhaul; the lee hands to tie the points; one stroke oarsman to attend the sheet, the other to assist the coxswain in reefing the mizen. No person need stand up. Do not luff up; check the sheets; lower enough to shift the tack

easily; gather the sheet aft, that the men may reach the foot of the sail without leaning over the lee gunwale; shift the sheet; tie away; slack the sheet; hoist; resume places, and haul aft. Should the mizen be reefed more quickly than the foresail, do not haul the mizen sheet aft until the boat has steerage way.

Remember, when running, that you cannot carry all the canvas on a wind that you can before it; therefore make ready for rounding to.

If the men are sitting to windward in a breeze, make them occupy their proper places before passing to leeward of a vessel.

If caught in a hard sudden squall, down helm at once, let fly the sheet, and lower the sail. In a moderate squall ease the sheet.

Trimming a boat requires great attention; if properly done, she should almost steer herself. A tendency to carry *lee* helm should be counteracted at once.

If there is any doubt about weathering a ship, or danger, "go about" in time; do not hug the wind, and drift crab-like on top of the ship or danger. If there is any doubt about the boat going round, have an oar ready.

Do not put the helm down too suddenly, or too far over. If the boat is in proper trim, her *ardency*, or natural tendency to carry weather helm, should be sufficient to bring her up in the wind if the helm be let go, after which a very little assistance with the helm should suffice to complete the evolution.

Do not overload a boat, particularly with men or sand. Sand is much lighter when dry than when wet. Remember that a laden boat carries her way longer than a light one.

In a strong breeze get the mast down before coming alongside.

Keep clear of a vessel with a stern-way on. Keep the boat stem on to a heavy sea.

Boats may ride out a heavy gale in the open sea, by lashing their spars, oars, etc., together, and riding to leeward of them, secured to them by a span. The sails should be loosed and attached to the spars; they contribute greatly to breaking the sea, and if weights be fastened to the clews, the boat's drift will be much retarded.

At night, or in thick weather at sea, or when far from the land, do not leave the ship without a compass, remembering before starting to get a bearing of the place or ship it is required to reach. Take a bearing of your own ship *on losing sight* of her by night or in a fog.

Place the compass in such a position that while the helmsman can use it, the instrument is as little as possible affected by the iron in the boat.

Make due allowance for the rate at which the tide is going past the ship. A current frequently sets close along shore in the opposite direction to the one that is setting past the ship; and therefore a little judgment may save a long pull. An inquiring sailor will learn more about local tides and currents by a chat with a waterman than can be found in books; and by observing the manœuvres of native boatmen, much labour and risk may be avoided.

In being towed by a vessel, if alongside, contrive to have the rope from as far forward as possible, so as to avoid riding at a short stay: never make it fast, but toggle it with a stretcher through the aftermost of the foremost sling bolts, so as to be able to slip in an instant. Steady it near the stem with the bight of the lazy painter.

In being towed astern, the closer the better.

In towing take the tow-line to the after thwart or foremost sternsling bolt, and toggle the bight with a stretcher.

In towing short round, do not attempt to turn before your leaders are round. The heaviest boats should be nearest the tow. Weighted boats tow best. Tow a spar by the small end.

On taking in the end of a warp, coil enough of it forward, so as to be able to make a bend the instant your boat reaches the place where the warp is to be made fast. Wet warps require very careful lashings.

If anchoring a boat on rocky ground, bend the cable to the crown of the anchor, and stop it to the ring before letting go; then, if the flukes jamb, the stop will carry away, and the anchor may easily be weighed.

The following notes on the management of boats rigged with what is generally known as the "De Horsey" rig, are by Vice-Admiral de Horsey:—

In setting a gaff mainsail, hoist the gaff up *square*, and belay the main halliards before peaking the sail. The tack lashing (if used at all) should never be hauled down until after the sail is set.

To set a gaff mainsail with only one hand, pull up the peak first, till the gaff is well up beyond its proper angle; then hoist the throat right up; and then peak the sail.

To take the first reef in a mainsail there is no need to lower the peak, *lowering the throat lowers both.* When the reef is in the sail will require re-peaking.

To shake out a reef, lower the peak well, so as to be able to sway the throat after the reef is out.

With six or eight hands in a launch you ought to be able to reef in stays, or shake out a reef, without losing any ground.

To set a mainsail well, take care to have the throat at its proper height, according to the number of reefs in; then peak the sail *until it slightly girts*. The tack is of little or no consequence.

With more than two reefs down, the horse is too far aft for the sheet. For this case a double block should be kept in each boom boat. Hook this block to a bolt in the side, and reeve the sheet through it, instead of through the block on the horse. Or, in blowy weather, keep a hook jigger in the boat for the purpose, instead of unreeving the sheet. This is the best plan, and very convenient for reefing and shaking out reefs.

In tacking, never ease the staysail or jib sheet. "Sticking out" the staysail should be unnecessary. When you "let draw," *ease* the staysail sheet over, never letting it shake. Do not let draw until sails are full and boat under command.

In wearing in a fresh breeze gather aft the main sheet when the wind is right aft, not before, and ease it off quickly after jibing. If you jibe without hauling aft, you will risk carrying away the jaws of the gaff.

In wearing, shift over the head sheets *before* the wind comes right aft, and always before jibing.

If, from carrying too much sail, or from being overladen, jibing is dangerous, settle your *main* halliards, or haul to the wind and tack, instead of wearing.

If taken in a squall, settle the *main* halliards, *never the peak first*.

When about to jibe to come alongside, take the staysail in, when before the wind, and before jibing.

When coming alongside *on a wind*, take the staysail in when you begin to shoot up, not before, for the obvious reason that although a boat will *run* without headsails, on a wind she becomes unmanageable, requires the helm hard up, loses her way, and drops to leeward.

When running, blowing fresh, do not ease the sheet enough to let the gaff go before the beam, or you will perhaps break the jaws.

In going alongside small ships, or even corvettes, remember that the gaff topsail reaches considerably higher than their main yard. In all ships keep *clear of their* davits, after main brace, and yard whips.

Shoving off to go to windward, have your sails set. To go to leeward, and round the stern, shove off under the staysail, not setting the mainsail until it will take on the right tack. By this means you will wear in a shorter space.

Keep your sails trimmed, staysail included. This would seem a superfluous caution. Yet it is not an uncommon thing to see sheets flat aft when going free, particularly when rounding to, to come alongside, the result of which is, that the boat makes leeway and loses her way.

Reefs in the staysail are more particularly required in a seaway than in a smooth harbour; but with more than one reef in the mainsail it is generally advisable to have the staysail reefed.

When the staysail is reefed, the standing part of the sheet should be shifted to the next bolt forward.

To get a launch's mast up and down with a full crew, the stay rove through its proper place suffices; if short handed, the main tackles may be taken forward.

To load your boat from a wharf, the quickest way is to use the main halliards. When loading, the gaff should be guyed out on the off beam.

To mount or dismount the gun, use the main tackles for a purchase, a train tackle to the stem to ease the gun aft or haul it forward, and a side tackle to the gunwale on each side abreast of the mast to steady the gun. With these precautions the gun may be quickly mounted, or dismounted in any sea. If the precaution of side tackles is neglected, even in a calm, the gun may swing over the side, injure several men, and capsize the boat. When mounting or dismounting the gun, hook and set up the main halliards to a bolt right aft for a back stay. The gun should be placed in the bottom of the boat abaft the mast.

To set a gaff topsail well, get the topmast well forward, the halliards well up, and the tack well down, but the sheet only moderately aft.

If a gaff topsail does not set well take it in. A topsail is a beautiful and valuable sail in light winds; but when blowing fresh, or if badly set, it is both harmful in point of speed, and dangerous for an open boat.

If, when taking in a gaff topsail, blowing fresh, it gets foul aloft, lower mainsail and all rather than send a man up.

When the topmast is struck, the sheave hole should be about two feet above the cap; but for ordinary service it is better down altogether, crosstrees

and all, the topmast gear being only intended for distant cruising, and for pleasure sailing.

When practicable choose the weather side for setting or taking in a topsail.

If, when racing, it is desirable to set or take in a topsail, or to do anything with the topmast, do it if practicable in stays, or, better still, before the wind.

When blowing too fresh for a gaff topsail on a wind, it should not be set before the wind; but if for exceptional reasons it be done (such as in racing) there should be a temporary extra backstay on the topmast led aft and to windward, taking care to let it go on coming to the wind, or when about to jibe.

In weather when a reef is likely to be wanted, it is preferable, even in racing, to have the topmast and crosstrees down altogether.

Landing in a Surf.—Viewed from seaward, a surf has never so formidable an appearance as when seen from the land; persons in a boat outside the broken water are therefore apt to be deceived by it. They should accordingly, if practicable, proceed along the land outside the surf, until abreast of a coastguard or lifeboat station, or fishing village, whence they might be seen by those on shore, who would then signalize to them where they might attempt to land with safety, or else warn them to keep off; or who might proceed in a lifeboat or fishing-boat to their aid; the generality of coast fishing-boats being far better able to cope with a surf than a ship's boat, and the coast boatmen being more skilful in managing boats in a surf than the crews of ships. If in the night, double precaution is necessary; and it will in general be much safer to anchor a boat outside the surf until daylight, than attempt to land through it in the dark.

Where a surf breaks at only a short distance from the beach, a boat may be anchored outside the surf, and veered, or backed in from her own anchor. In such a case care should be taken that the cable is of sufficient length to permit of the boat's reaching the beach from a safe position outside the line of breakers. The cable should be bent, and everything be in readiness for landing before approaching the shore; on reaching the edge of the breakers, the bow and after oars should be laid in, the bow man attending to the anchor and cable, the coxswain standing by with a small line for a stern-fast. On the anchor being let go the rudder should be unshipped, and the boat backed in steadily but fearlessly; care being taken by the bow man to keep her bow to the sea by not letting her take the cable too fast. On reaching

the shore the coxswain should either jump overboard with the stern-fast, or throw it to any persons who may be on the beach. This stern-fast steadies the boat, keeps her bow to the sea, and facilitates the landing. On the landing being effected the boat can be hauled out to her anchor, taking care if she is wanted to return to the shore to let one end of the stern-fast remain on the beach.

Going over a bar against a surf, avoid a heavy breaker if you can; if not, *pull at it* with all your might, cautioning your men not to lose their oars.

Going in before a surf, watch your chance of a partial smooth, which generally occurs after a succession of heavy breakers. When a breaker is overtaking you, there is generally no time to turn round bow on; under these circumstances, *back at it* with all your might, giving way in again as soon as it has passed the middle of the boat.

The reason for pulling at, or backing at a surf, is to let it pass by as quickly as possible, as the principal danger lies in being carried along with a surf.

Remember that when carried along with a surf the rudder is powerless, as the water is going with the boat. Hence the importance of a steer oar.

The best time to go in over a bar is generally three-quarter flood; and for coming out, the top of high water. With regard to the time of day, the early morning is nearly always best.

Rules published by the Royal National Lifeboat Institution, on the Management of Open Rowing Boats in a Surf; Beaching them, etc.

In Rowing to Seaward.

As a general rule speed must be given to a boat rowing against a heavy surf.

Indeed, under some circumstances, her safety will depend on the utmost possible speed being attained on meeting a sea.

For, if the sea be really heavy, and the wind blowing a hard on-shore gale, it can only be by the utmost exertions of the crew that any headway can be made. The great danger then is, that an approaching heavy sea may

carry the boat away on its front, and turn it broadside on, or up-end it, either effect being immediately fatal. A boat's only chance in such a case, is to obtain such way as shall enable her to pass end on, through the crest of the sea, and leave it as soon as possible behind her. Of course if there be a rather heavy surf, but no wind, or the wind off shore, and opposed to the surf, as is often the case, a boat might be propelled so rapidly through it, that her bow would fall more suddenly and heavily after topping the sea, than if her way had been checked; and it may therefore only be when the sea is of such magnitude, and the boat of such a character, that there may be chance of the former carrying her back before it, that full speed should be given to her.

It may also happen that, by careful management under such circumstances, a boat may be able to avoid the sea, so that each wave may break ahead of her, which may be the only chance of safety in a small boat; but if the shore be flat, and the broken water extend to a great distance from it, this will often be impossible.

The following general rules for rowing to seaward may therefore be relied on:—

1. If sufficient command can be kept over a boat by the skill of those on board her, avoid or "dodge" the sea if possible, so as not to meet it at the moment of its breaking or curling over.

2. Against a head gale and heavy surf, get all possible speed on a boat on the approach of every sea which cannot be avoided.

If more speed can be given to a boat than is sufficient to prevent her being carried back by a surf, her way may be checked on its approach, which will give her an easier passage over it.

On Running before a Broken Sea, or Surf, to the Shore.

The one great danger, when running before a broken sea, is that of *broaching-to*. To that peculiar effect of the sea, so frequently destructive of human life, the utmost attention must be directed.

The cause of a boat's broaching-to, when running before a broken sea or surf, is, that her own motion being in the same direction as that of the sea, whether it be given by the force of oars or sails, or by the force of the sea itself, she opposes no resistance to it, but is carried before it. Thus, if a boat be running with her bow to the shore, and her stern to the sea, the effect of a surf or roller, on its overtaking her, is to throw up the stern, and as a

consequence to depress the bow; if she then has sufficient inertia (which will be proportional to weight) to allow the sea to pass her, she will in succession pass through the descending, the horizontal, and the ascending positions, as the crest of the wave passes successively her stern, her midships, and her bow, in the reverse order in which the same positions occur to a boat propelled to seaward against a surf. This may be defined as the safe mode of running before a broken sea.

But if a boat, on being overtaken by a heavy surf, has not sufficient inertia to allow it to pass her, the first of the three positions above enumerated alone occurs—her stern is raised high in the air and the waves carries the boat before it, on its front, or unsafe side, sometimes with frightful velocity, the bow all the time being deeply immersed in the hollow of the sea, where the water, being stationary, or comparatively so, offers a resistance, whilst the crest of the sea, having the actual motion which causes it to break, forces onward the stern, or rear end of the boat.

A boat will, in this position, sometimes aided by careful oar-steerage, run a considerable distance until the wave has broken and expended itself. But it will often happen, that if the bow be low, it will be driven under water, when the buoyancy being lost forward, whilst the sea presses on the stern, the boat will be thrown (as it is termed) end over end; or if the bow be high, or it be protected, as in most lifeboats, by a bow air-chamber, so that it does not become submerged, that the resistance forward, acting on one bow, will slightly turn the boat's head, and the force of the surf being transferred to the opposite quarter, she will in a moment be turned round broadside by the sea and be thrown by it on her beam-ends, or altogether capsized. It is in this manner that most boats are upset in a surf, especially on flat coasts, and in this way many lives are annually lost amongst merchant seamen when attempting to land, after being compelled to desert their vessels.

Hence it follows that the management of a boat, when landing through a heavy surf, must, as far as possible, be assimilated to that when proceeding to seaward against one, at least so far as to stop her progress shoreward at the moment of being overtaken by a heavy sea, and thus enabling it to pass her. There are different ways of effecting this object:—

1. By turning a boat's head to the sea before entering the broken water, and then backing in stern foremost, pulling a few strokes ahead to meet each heavy sea, and then again backing astern. If a sea be really heavy and a boat small, this plan will be generally the safest, as a boat can be kept more under command when the full force of the oars can be used against a heavy surf, than by backing them only.

2. If rowing to shore with the stern to seaward, by backing all the oars on the approach of a heavy sea, and rowing ahead again as soon as it has passed to the bow of the boat, thus rowing in on the back of the wave; or, as is practised in some lifeboats, placing the after-oarsmen with their faces forward, and making them row back at each sea on its approach.

3. If rowed in bow foremost, by towing astern a pig of ballast or large stone, or a large basket, or canvas bag termed a "drogue" or drag, made for the purpose, the object of each being to hold the boat's stern back, and to prevent her being turned broadside to the sea or broaching-to.

A boat's sail bent to a yard, and towed astern loosed, the yard being attached to a line capable of being veered, hauled, or let go, will act as a drogue, and tend much to break the force of the sea immediately astern of the boat.

Heavy weights should be kept out of the extreme ends of a boat; but when rowing before a heavy sea the best trim is deepest by the stern.

A boat should be steered by an oar over the stern, or on one quarter when running before a sea, as the rudder will then at times be of no use. If the rudder be shipped, it should be kept amidships on a sea breaking over the stern.

The following rules may therefore be depended on when running before, or attempting to land, through a heavy surf or broken water:—

1. As far as possible avoid each sea by placing the boat where the sea will break ahead or astern of her.

2. If the sea be very heavy, or if the boat be very small, and especially if she have a square stern, bring her bow round to seaward and back her in, rowing ahead against each heavy surf that cannot be avoided sufficiently to allow it to pass the boat.

3. If it be considered safe to proceed to the shore bow foremost, back the oars against each sea on its approach, so as to stop the boat's way through the water as far as possible, and if there is a drogue, or anything in the boat that may be used as one, tow it astern to aid in keeping the boat end on to the sea, which is the chief object in view.

4. Bring the principal weights in the boat towards the end that is to seaward, but not to the extreme end.

5. If a boat, worked by sails or oars, be running under sail for the land *through a* heavy sea, her crew should, under all circumstances, unless the

beach be quite steep, take down her masts and sails before entering the broken water, and take her to land under oars alone, as above described.

If she has sails only, her sails should be much reduced, a half-lowered foresail or other small head-sail being sufficient.

Beaching or Landing through a Surf.*

The running before a surf or broken sea, and the beaching or landing of a boat, are two distinct operations; the management of boats, as above recommended, has exclusive reference to running before a surf where the shore is so flat that the broken water extends to some distance from the beach. Thus on a very steep beach, the first heavy fall of broken water will be on the beach itself, whilst on some very flat shores there will be broken water as far as the eye can reach, sometimes extending to even four or five miles from the land. The outermost line of broken water, on a flat shore, where the waves break in three or four fathoms water, is the heaviest, and therefore the most dangerous, and when it has been passed through in safety, the danger lessens as the water shoals, until, on nearing the land, its force is spent and its power harmless. As the character of the sea is quite different on steep and flat shores, so is the customary management of boats on landing different in the two situations. On the flat shore, whether a boat be run or backed in, she is kept straight before or end to the sea until she is fairly aground, when each surf takes her farther in as it overtakes her, aided by the crew, who will then generally jump out to lighten her, and drag her in by her sides. As above stated, sail will, in this case, have been previously taken in if set, and the boat will have been rowed or backed in by oars alone.

On the other hand, on the *steep* beach, it is the general practice, in a boat of any size, to retain speed right on to the beach, and in the act of landing, whether under oars or sail, to turn the boat's bow half round towards the direction from which the surf is running, so that she may be thrown on her broadside up the beach, when abundance of help is usually at hand to haul her as quickly as possible out of the reach of the sea. In such situations, we believe, it is nowhere the practice to back a boat in stern foremost under oars, but to row in under full speed as above described.

* See also page 282.

BOARDING.

Boarding a Wreck, or a Vessel under Sail, or at Anchor in a Heavy Sea.

THE circumstances under which lifeboats and other boats have to board vessels, whether stranded or at anchor, or under way, are so various that it would be impossible to draw up any general rule for guidance. Nearly everything must depend on the skill, judgment, and presence of mind of the coxswain or officer in charge of the boat, who will often have those qualities taxed to the utmost, as undoubtedly the operation of boarding a vessel in a heavy sea or surf is frequently one of extreme danger.

It will be scarcely necessary to state that, whenever practicable, a vessel, whether stranded or afloat, should be boarded to leeward, as the principal danger to be guarded against must be the violent collision of the boat against the vessel; or her swamping or upsetting by the rebound of the sea; or by its irregular direction on coming in contact with the vessel's side; and the greater violence of the sea on the windward side is much more likely to cause such accidents. The danger must, of course, also be still further increased when the vessel is aground and the sea breaking over her. The chief danger to be apprehended on boarding a stranded vessel on the lee side, if broadside to the sea, is the falling of the masts; or if they have been previously carried away, the damage or destruction of the boat amongst the floating spars and gear alongside. It may therefore, under such circumstances, be often necessary to take a wrecked crew into a lifeboat from the bow or stern, otherwise a rowing boat, proceeding from a lee shore to a wreck, by keeping under the vessel's lee, may use her as a breakwater, and thus get off in comparatively smooth water. This is accordingly the usual practice in the rowing lifeboats. The larger sailing lifeboats, which go off to wrecks on outlying shoals, are, however, usually anchored to windward of stranded vessels, and then veered down to 100 or 150 fathoms of cable, until near enough to throw a line on board.

The greatest care under these circumstances has of course to be taken to prevent actual contact between the boat and the ship.

In every case of boarding a wreck or vessel at sea, it is important that the line by which a boat is made fast to a vessel should be of sufficient length to *allow of* her rising and falling freely with the sea; and every rope should be

kept in hand ready to cut or slip it in a moment if necessary. A sharp knife should be at hand.

Before going alongside a vessel under weigh and hove to, observe if she have head or sternway, and in any case get the masts down before closing her. Wait until the ship has gathered headway, and then go alongside.

Do not shove off during sternway, else the ship in setting to leeward and falling off may bury the boat under her bows, or with her stem and dolphin striker cut the boat down.

In being towed by a vessel, if alongside, contrive to have the rope from as far forward as possible, so as to avoid riding at a short stay; never make it fast, but toggle it with a stretcher through the aftermost of the foremost sling bolts, so as to be able to slip in an instant; steady it near the stem with the bight of the lazy painter.

In being towed astern, the closer the better.

MEN-OF-WAR'S BOATS.

THE following remarks and drawings for rigs suitable for men-of-war's boats were kindly furnished by Vice-Admiral de Horsey, to whom, as an admitted authority, the compiler applied. At the time this request was made it was intended to go more fully into the subject, and give many more examples from different authorities; but it has been found impossible to devote sufficient space to do this, and since then an excellent little work treating especially on boats and boat-sailing has been brought out by Captain Fitz-Gerald, R.N., and the reader is referred to it for much useful information and descriptions of rigs of all kinds.

Before giving descriptions of the principal rigs recommended for men-of-war's boats, I may premise that, viewing the manifold duties for which they are required, and that sailing is by no means their chief requirement, their equipment with masts and sails is of necessity simpler than, and perhaps different to, what it otherwise would be. In any case, only *one* rig, and that especially suited for service, should be allowed for each boat. Gripes and false keels should not be permitted, with this exception, that in the case of launches a slight addition—say three inches—of keel aft, tapered to nothing forward, appears unobjectionable, and adds materially to the sailing qualities and strength of the boat. No ballast is admissible, except water, the boat's gear, and the crew. For boom boats, casks painted and marked for each boat are preferable to barricoes.

The principal qualifications for boom boats (not being steamers) may be thus enumerated: Speed, safety, bad weather qualities, handiness, quickness in getting mast up and down, facility for mounting and dismounting gun, laying out anchors, loading with provisions or water, sailing with water ballast only, absence of gripe, so as to be able to beach safely.

For smaller boats some of the above qualifications are not necessary; but all require speed, safety, simplicity of rig, no gripe, and *no* iron ballast.

In view of the above, the rigs I recommend are, gaff mainsail and staysail for sailing boom boats, a jury rig of two standing lugs and staysail for steam pinnaces, dipping lug and mizen for cutters and jolly boats, sprit-sail and jib for dingeys. With regard to admiral's barges, galleys, and gigs, it appears useless to lay down a rule, as opinions vary so much. The rigs I have found most suitable are, two sliding gunters and jib for a barge, three lateens for a galley, and two for a gig.

It will be observed that all the sails in the following sketches have reefs of ample size. This I hold to be essential. A boat may, and sometimes does, get caught by a strong wind, having started in fine weather. If unable to carry proper low canvas, the crew would soon become exhausted in rowing, and if on a lee shore, and landing be impracticable, loss of boat and crew may result. The stronger the *wind power*, the more reason (and often necessity) there is for using it in preference to *man power*.

Forty-two-foot Launch.—Figure 1 shows the rig I recommend for launches (and sailing pinnaces), it being clearly understood that the mainsail and staysail alone constitute the regular working rig. The topsail and all gear belonging to it, including topmast and crosstrees, should never be aloft except for special services and for pleasure sailing, and then only in light winds.

For speed, handiness, getting up mast, getting gun up and down, loading from a wharf, laying out anchors, etc., nothing can beat this rig. If properly fitted, one minute is ample time for getting under sail from being under oars with mast down, and *vice versâ*. The rigging should consist of a stay long enough to reeve through the roller at the stem when the mast is down, a pair of shrouds each side, the foremost leg setting up with a lanyard abreast of the mast, and the after leg, or pendant, fitted with a double block halfway down the mast, so as to form a main tackle, and to set up two feet abaft the foremost leg. No runners are required, the main tackle answers better. No iron blocks, or iron hoops, no wire rope (except perhaps wire cord for topmast backstays), no iron crosstrees; in fact, nothing in an open boat should *be of metal* where hemp and wood will answer better.

There should be no boom, or bowsprit, or jib, or mizen—all these are impediments for real work (as you will find, if you have to send a stream anchor and cable to a driving merchant ship on a dark night, and the overworked steam pinnace is not available, or has not steam up). A mizen is most troublesome, a boom necessitates a jib to balance it, a jib requires a gripe, which latter is a serious detriment when landing on a beach, and adds to the risk of beaching in a surf, or going through a surf at all.

The dimensions of spars are as follows:—

	ft.	in.
Mast, extreme length ...	31	6
„ head	3	10
„ housing	2	4
„ size at partners ...	0	7
„ „ hounds ...	0	6
„ rake, 1½ in. to the foot.		
„ position, from fore side of stem to fore side of mast	17	0
Gaff, extreme length ...	19	6
Gaff, greatest diameter ...	0	4
„ least „ ...	0	2
Topmast, lower side of fid hole to stops	17	9
Topmast pole	1	6
„ size at cap ...	0	3½
Topsail yard	21	3
„ diameter at slings	0	3¼
Crosstrees	9	4

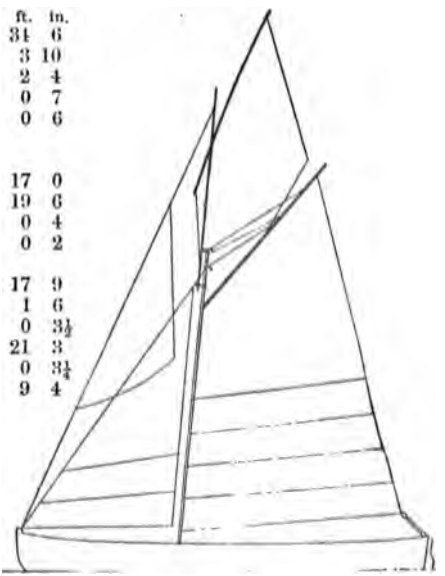


Fig. 1. Scale $\frac{1}{25}$ inch to the foot.

The best method of fitting the partners is shown in Fig. 2. A hook clamp, fixed on the mast, hooks on a bolt which ties the partner carlings together. Guide pieces are fitted from the carlings to the step, to take the

heel of the mast. The mast, when upright, is locked by a drop paul on a hinge, which paul has an eyebolt and lanyard for lifting it when getting the mast down. By this method a launch's mast may be raised or lowered with ease and free from risk, however much the boat may be rolling in a sea.

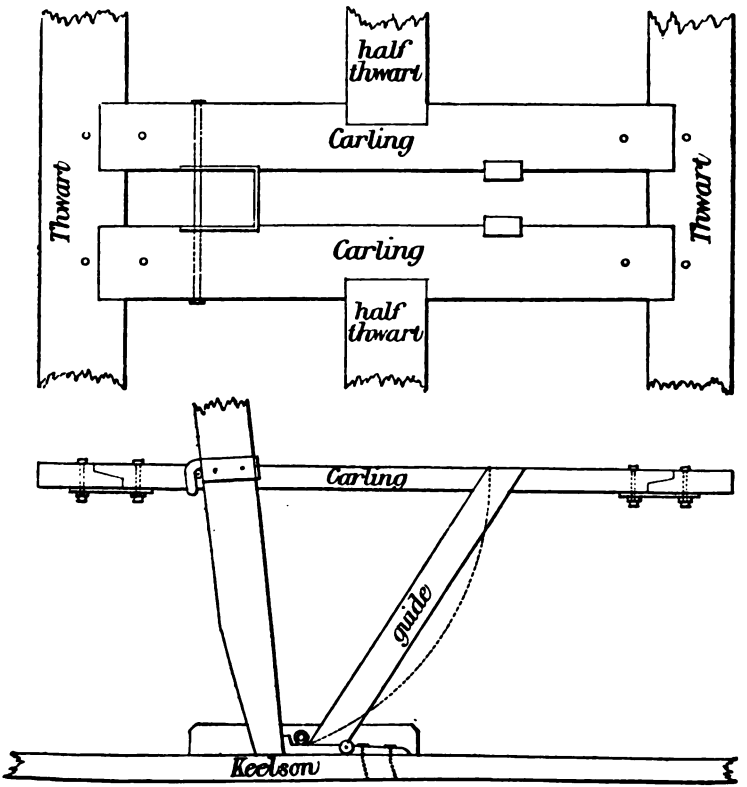


Fig. 2. Scale ½ inch to the foot.

Thirty-seven-foot Steam Pinnace.—Viewing the quantity of torpedo and other fittings of a steam pinnace, it is doubtful whether she should be rigged at all. I am in favour of a jury rig of two standing lugs and jib, as being the easiest to put aside out of the way of the boiler and funnel. Sail is of great assistance for long distances, and would in many cases, where coal is not procurable, enable a steam pinnace to arrive at the place where her services are required with her coal supply but little reduced. A rig of some sort is also a stand-by in case of a breakdown; but for harbour work no masts or sails should be in the boat.

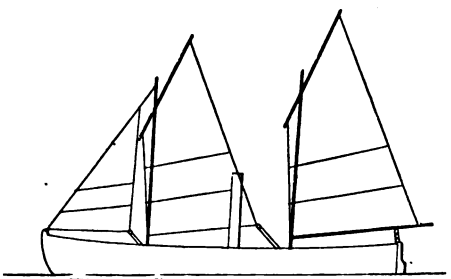


Fig. 3. Scale $\frac{1}{10}$ inch to the foot.

The dimensions of the spars shown in Fig. 3 are as follows:—

	ft.	in.
Mainmast, above gunwale	18	0
„ rake, 1 in. to the foot.		
„ position, taffrail to after side of mast ...	11	0
Mainyard	13	0
Mainboom	13	8
Foremast, above gunwale	16	6
„ rake, $\frac{1}{2}$ in. to the foot.		
„ position, fore side of stem to fore side mast	10	7
Foreyard	12	3

A very useful fitting for a steam pinnace is a towing post, placed in the partners of the mainmast. It should be fitted with a hook, swivelling on a bolt in the post head, with a hoop on the post to prevent it from splitting. The bowling of a tow rope can thus be instantly hooked to the post. The use of a towing post enables the towing vessel (like a tug) to steer well, notwithstanding the yawing of the vessel towed; and it carries the tow rope clear of the sitters' heads.

Thirty-foot Cutter.—Fig. 4, of a thirty-foot cutter with a dipping lug and mizen, is only a slight alteration from the ordinary service cut of cutters' sails. This rig (although for many and obvious reasons unsuited to large boom boats) is, I believe, the best of all for speed, and has the least gear. It is also very suitable to sitters, and is decidedly a beautiful rig when the sails are well cut. Its drawbacks are unhandiness for short tacking, its extreme danger if taken aback (in which position the sails will not come down), and the fact that none but a full and highly trained crew can safely manage it.

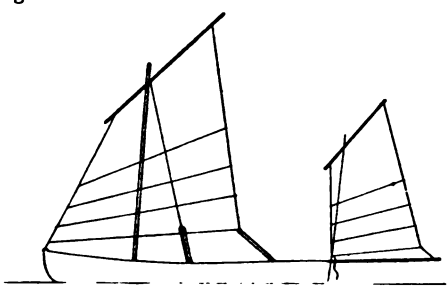


Fig. 4. Scale $\frac{1}{50}$ inch to the foot.

Boats rigged with dipping lug and mizen should have no rigging to the mast, and no masthead iron aloft. The sail should hoist with a single tie rove through the mast, and set up with a treble purchase (two single blocks). The halliards should be taken to the gunwale well aft and to windward. Let the hook for the halliard block be a fixed one on the gunwale, and the lower block strap be fitted with an eye and thimble, and with a lanyard to hold it by when shifting from side to side in tacking or wearing.

In tacking or wearing the sail should be (if so fitted) dipped before all in old-fashioned way, except when several reefs are down, in which case the sail must be lowered right down, and dipped *abaft all.*

The dimensions of spars are as follows:—

	ft.	in.		ft.	in.
Mast, extreme	24	0	Mizen-mast, above transom	13	8½
„ rake, ¾ in. to the foot.			„ rake, 1¾ in. to the ft.		
„ position, fore side of stem to fore side of *mast*...	9	2	„ position, against transom.		
Foreyard	14	6	Mizen-yard	8	6
			Bumpkin, outboard... ...	11	0

Thirty-four-foot Admiral's Barge.—A sliding gunter rig, as shown in Fig. 5, is perhaps most suitable for an admiral's barge, as the masts are not long enough to interfere, when boated, with the stern sheets. The masts require single shrouds, and the mainmast two slight main stays, to set up with treble purchases, one on each side, so as to keep the weather one only set up.

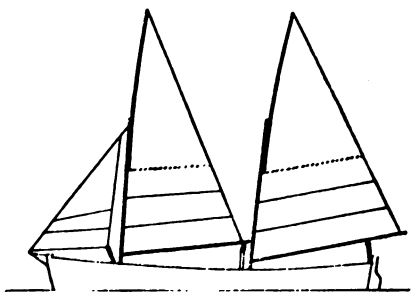


Fig. 5. Scale $\frac{1}{20}$ inch to the foot.

The dimensions of spars are as follows:—

	ft.	in.
Mainmast, above thwart	16	6
„ rake, $1\frac{3}{8}$ in. to the foot.		
„ position, after side of mast to stem ...	12	0
Mainyard	17	6
Mainboom	16	0
Foremast, above thwart	16	0
„ rake, $1\frac{1}{4}$ in. to the foot.		
„ position, fore side of stem to mast ...	8	2
Foreyard	17	0
„ boom	13	3
Bowsprit, iron, with stay	2	0

Thirty-two-foot Galley.—The lateen rig, shown in Fig. 6, is the one I have found best suited to long narrow boats of the galley type. It is decidedly good for speed, and admits of the amount of sail being easily proportioned to the strength of wind. Its objections are the length of the yards when boated, inability to row all the oars when sailing, and that an awkward hand will perhaps drop the mainyard on your head.

The masts (which are termed main, fore, and bow) are all three similar in the partners, and therefore interchangeable. The boat may thus be sailed with one, or two, or three sails, and yet have her sail properly balanced. It is convenient to have a fourth mast and sail a size smaller, so as to use the set of three smallest masts and sails in windy weather. The halliards are single rove athwartships through the mast and belayed to a cleat on the mast. No shrouds. A tack line from the lower yard-arm hooks to an eye-bolt on the fore side of the mast. It is convenient for reefing to have a long head earing, and to bring the sail to the yard with grummets instead of a lacing.

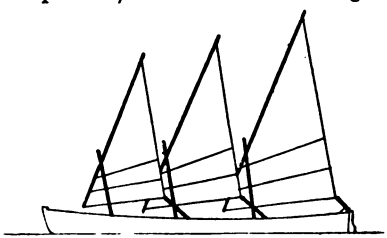


Fig. 6. Scale $\frac{1}{20}$ inch to the foot.

The dimensions of spars are as follows:—

	Bowmast.	Foremast.	Mainmast.
	ft. in.	ft. in.	ft. in.
Length of Yards ..	17 0	20 0	23 0
Length of Masts ..	7 6¾	8 3½	9 0
Rake (forward) ..	12 degrees.	9½ degrees.	7 degrees.
Stepped	Aft side of No. 1 thwart.	10 ins. abaft after side of No. 3 thwart (in a carling).	Aft side of after thwart.

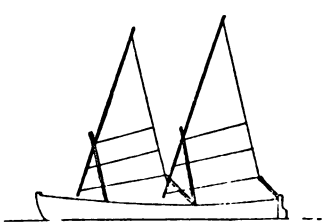


Fig. 7. *Scale $\frac{1}{20}$ inch to the foot.*

Twenty-five-foot Gig.—The same remarks as those concerning the thirty-two-foot galley lateen apply to the twenty-five-foot gig, if fitted with two lateens as shown in Fig. 7; except that, with only two masts, a third step is fitted amidships for using one sail only when desired.

The dimensions are as follows :—

	Foremast.	Mainmast.
	ft. in.	ft. in.
Length of Yards..	18 0	20 0
Length of Masts..	8 0	8 6
Rake (forward)	12 degrees.	10 degrees.
Stepped	Aft side of No. 2 thwart.	Aft side of after thwart.

Fourteen-foot Dingey.—Fig. 8 shows a service fourteen-foot dingey with a sprit rig. She is slightly under-rigged to be able to boat her spars conveniently, and to suit the boys who generally manage her.

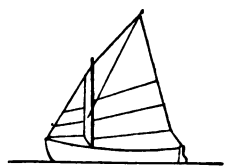


Fig. 8. Scale $\frac{1}{20}$ inch to the foot.

The dimensions are:—

	ft.	in.
Mast, above gunwale	8	6
„ stepped, abaft stem	4	9
Sprit	11	0

BOAT RACING.

THE following rules were drawn up for the Mediterranean Fleet Regatta of 1883:—

General Rules.—1. The committee reserve to themselves the power of altering or increasing the course if necessary, or of altering the days for pulling and sailing according to the weather.

2. In races where a second prize is given, 3 boats to start or no second prize; where a third prize is given, five boats to start or no third prize. No prize will be given for a walk over.

3. All objections to be lodged by semaphore to flagship within one hour of the objecting boat passing the winning-post. The decision of the committee to be final.

4. Entries to close one clear day before the race takes place.

5. All boats to carry a distinguishing flag, 17 in. by 14 in.

6. These rules should be read to all competing crews.

Rowing Regulations.—1. The course to be laid out by the committee and marked with flag-boats, or buoys, as necessary.

2. All flag-boats or buoys to be left on the port hand, and in rounding these, outside boats to give way to inside boats, and boats astern to go outside of boats ahead of them. If a buoy or flag-boat be touched by the hull of a competing boat, or by any of her crew, such competing boat will be disqualified.

3. Any boat that in the opinion of the committee wilfully or from neglect fouls any other boat shall be disqualified.

4. Each double-banked boat is to carry an officer in addition to the coxswain.

5. In no case (except in Nos. 12, 20, 21) is any boat to pull other than the regulation number of oars, and those oars must be pulled on the proper thwarts.

6. Entrance fees for No. 2, 6*d.* for each officer; for No. 12, 1*s.*; and for No. 18, 5*s.* A prize to be bought with the entrances for the winning crews in each race.

7. In race No. 4, the cutters must be pulled by the crews absolutely belonging to the boats when manned and armed, and in case of sickness the crews filled up in the usual manner from the spare hands. No men belonging to one cutter can pull in another.

8. The coxswain of each boat must belong to the class of which his boat's crew is composed.

9. No. 2 race is only for ships' launches or twelve-oared cutters.

Sailing Regulations.—1. Service rigs are to be strictly adhered to. By service rig is understood that used in manning and arming boats. Gaff topsails or bowsprits may not be carried. Awnings allowed, but no extra spars for rigging out.

2. Iron ballast or false keels are not to be used. Water or wood ballast only allowed. Ballast may be started if desirable, but any boat taking it in again will be disqualified.

3. *Boats to* carry full crews and their own anchor and cable.

4. Double-banked boats are to carry an officer, except in ships where midshipmen are not borne.

5. All boats in the proximity of any boat that may capsize are to render immediate assistance, and boats rendering such assistance shall have the option of sailing the two winning boats provided the committee are of opinion that those boats stood a chance of taking either of the prizes. In this case the relative positions of the two winning boats with respect to each other in the first race will be adhered to.

6. In the event of a boat capsizing in the early part of the race, the committee have the power of recalling all the boats and starting them afresh.

7. Any boat capsizing, both the officer and the boat shall be excluded from racing again in that particular race.

8. Any boat using propelling power, such as oars, balers, hands or feet in the water, shall be disqualified.

9. The "rule of the road" with regard to meeting, or passing, or giving way to another, is to be strictly adhered to; and any boat purposely fouling another will be disqualified.

10. Any boat anchoring must weigh her anchor on again starting.

11. No committee member is to sail a boat unless a substitute is found.

Entrance fees to be as follows:—

Boats sailed by Midshipmen, Warrant Officers, or Petty Officers, 2*s*.
„ Sub-Lieutenants, 3*s*.
„ any other Officer, 5*s*.

These fees to be applied as the committee shall decide before the sailing day.

Courses.

Rowing.	*Sailing.*
Long, about 2½ miles.	Long, three times round, a course of 4 miles.
Middle, „ 1¾ „	
Short, „ 1 „	Short, twice round.

First Day—Rowing Races.

No. of Race.	Boats.	Pulled by.	Course.
1	Cutters, 12 oars	Open	Long
2	Cutters, 10 oars	Gun-room Officers	Short
3	Whalers and Gigs, 4 or 5 oars	Marines	Middle
4	Launches	Open	,,
5	Cutters, 12, 10, and 8 oars	Proper crews	,,
6	Whalers and Gigs, 4 or 5 oars	Boys	,,
7	Pinnaces	Stokers	,,
8	Cutters, 12 oars	Marines	,,
9	Galleys, 6 oars	Open	Long
10	Whalers and Gigs, 4 oars	,,	,,
11A.	Cutters, 10 oars	,,	,,
11	Cutters, 8 oars	,,	,,
12	Galleys and Gigs	Gun-room Officers	Middle
13	Pinnaces	Open	Long
14	Cutters, 12 or 10 oars	Boys	Middle
15	Whalers and Gigs, 5 oars	Open	Long
16	Launches	Marines	Middle
17	Cutters, 12 oars	Stokers	Long
18	Galleys and Gigs	Officers	Middle
19	Cutters, 10 oars	Artificers and Mechanics	Short
20	Dingeys	Open	,,
21	Galleys and Gigs	Domestics	,,
22	All-comers (Service Boats), any number of oars	Open	Long

Second Day—Sailing Races.

No. of Race.	Boats.	Course.
1	Launches	Long Course
2	Pinnaces	,, ,,
3	Cutters over 28 ft. and Barges	,, ,,
4	Cutters 28 ft. and under	,, ,,
5	Single-banked Boats	,, ,,
6	Dingeys and Skiffs	Short Course—any rig, and false keels.
	Barges allow cutters 11 *minutes.*	

Bumboat Race. Duck Hunt. Aquatic Games.

Rules for Sailing Handicap, Sept. 24, 1883.

1. Any rig allowed. False keels allowed.

2. Water or wood ballast only allowed. Ballast may be shifted or started but not taken in.

3. All boats to be sailed by officers.

4. Boats are to pull or be towed up to leeward of the starting hawser, and wait to make fast to the buoys until told off by the starter.

5. Boats are to start with all sails down, except sails laced to masts all the way down, when they must be brailed up, or if sprit-sails, the sprits out.

6. Launches, pinnaces, barges, and cutters over 28 feet make fast to the hawser. Cutters 28 feet and under ahead of them. Single-banked boats ahead of these.

7. At the 1st gun, single-banked boats to start.
After 4 minutes, at 2nd gun, cutters 28 feet and under to start.
After 5 minutes, at 3rd gun, cutters over 28 feet, barges, and pinnaces to start.
After 9 minutes, at 4th gun, launches to start.

8. (Paragraph 8 refers to value of prizes.)

9. Entrance, 5*s*. per boat, which will be taken to increase all prizes, or, if the committee deem fit, to make 2nd and 3rd for the crews of boats.

10. Entries to be on board flagship before noon on Saturday, the 22nd.

11. No steamboat to be entered, as they will be required on the day of the race.

12. All boats to carry their ship's racing flag (17 in. × 14 in.) at the masthead; and if two or three boats of the same denomination are entered by the same ship the following pendant is to be under the racing flag:

1st launches, 1st cutters, etc.—a red pendant 4 in. × 8 in. long.
2nd launches, 2nd cutters, etc.—a white pendant 4 in. × 8 in. long.
3rd launches, 3rd cutters, etc.—a blue pendant 4 in. × 8 in. long.

13. All objections to be lodged on board flagship (by semaphore) within one hour of the objecting boat passing the post.

14. The general recall will be hoisted at the main of the flagship should it

fall calm or there be a chance of the boats not being back by sunset. In this case the race will be run another day.

15. Should the day not suit, the race will be put off by signal.

16. Length of course about twelve miles, leaving mark-boats on port-hand.

17. No dingeys or skiffs to enter.

Notes for Boats.

The number of the race will be hoisted at the main of flagship eight minutes before that race is to start for boats to assemble at starting-post.

1. Any boat touching the buoy or mark-boat to be disqualified.

2. The inside boat is to pull a straight course for the mark-boat or buoy and round it closely, and the outside boats are to give room for the inside boats to do so.

3. In sailing and pulling races, it is to be clearly understood that while in a straight course any boat taking the water of another boat does so at her own risk, and that while doing so, if the rear boat spurts and touches her or her oars, she forfeits all claim to a prize.

4. **For Sailing Boats.**—When rounding any mark or obstruction to sea room, outside boats must give inside boats room to pass clear, whether they are close hauled or free or lee or weather boat.

5. In sailing to windward the boat on the port tack shall invariably give way to the boat on the start tack; any boat disobeying shall forfeit all claim to a prize.

6. If two boats be standing for the shore, or towards any vessel, and the boat to leeward be likely to run aground or foul of such vessel, and be unable to stay without coming into contact with the windward boat, the windward boat must be put about on being hailed by the leeward boat to do so; such boat, however, must tack at the same time as the one she hails.

7. Any boat bearing away or altering her course to leeward, provided there is no obstruction in the way, thereby compelling another boat to alter her course, shall be disqualified. A boat may luff as she pleases to prevent any other boat passing her to windward, but is not allowed to go about (if she does, and fouls, she will forfeit all claim to a prize). No boat is allowed *to bear away* to prevent a boat passing her to leeward.

8. When two boats are sailing on a wind or free along a weather shore, the weathermost boat, being in such a position that she cannot bear away without fouling, shall be at liberty to hail the lee one to give her room to avoid the shore, and the lee boat is bound to bear away sufficiently to give the room necessarily required by the weather boat, or failing to do so shall forfeit all claim to a prize.

9. In the case of a man or men overboard, boats are to use their utmost endeavour to render assistance, and should it be proved that any boat or boats that could have rendered assistance did not do so, they will forfeit all claim to a prize. And if it should appear that any boat or boats having a chance of winning shall have lost that chance by assisting, the committee shall cause the winning boat or boats and the boat or boats delayed by the assistance rendered to race over such course or part of the course as they may consider just. The boat which caused the delay to be disqualified.

10. In all cases not met by these rules the "Rule of the road" to be adhered to.

11. Where the above rules or the "Rule of the road" is infringed, such cases being proved to the satisfaction of the committee, the boat or boats in fault to forfeiit all clam to a prize.

12. All objections to be lodged with the committee:

For sailing races, within one hour of the objecting boat passing the winning-post.

For pulling races, within half an hour of the objecting boat passing the winning-post.

Extracts from the Sailing Rules of the Yacht Racing Association.

Measurement of Tonnage.—The tonnage of every yacht entered to sail in a race shall be ascertained in the manner following: the length shall be taken in a straight line at the deck, from the fore part of the stem, to the after-part of the sternpost; from which, deducting the breadth, the remainder shall be esteemed the length to find the tonnage; the breadth shall be taken from outside to outside of the planking, in the broadest part of the yacht, and no allowance shall be made for wales, doubling planks, or mouldings of any kind: then multiplying the length by the breadth, and the product by half the breadth, and dividing the result by 94, the quotient shall be deemed the true tonnage; provided always that if any part of the stem or stern-post, or other part of the vessel at or below the load water-line, project beyond the

length taken as above mentioned, such projection or projections shall, for the purposes of finding the tonnage, be added to the length taken as stated.

In the case of a yacht whose stern-post has an elbow, the length shall be taken to a point where the stern-post, if its rake were continued, would cut the deck-line; and in measuring schooners or other yachts with overhanging stems, the length shall be taken to a point half the distance between the fore part of the stem at the deck line and a perpendicular to the true load water-line at its fore end. The fraction $\frac{1}{2}$ and over to be counted as a ton, and any fraction under $\frac{1}{2}$ to be disregarded.

If, from any peculiarity in the construction of a yacht, or other cause, the measurer shall be of opinion that this rule will not measure the yacht fairly, he shall report the circumstances to the council or sailing committee, who, after making such inquiries as they consider necessary, shall award a certificate of tonnage accordingly. The certificate of tonnage of the Yacht Racing Association shall be deemed a yacht's true racing tonnage, so long as she remains unaltered.

Meeting end on.—If two yachts are meeting end on, or nearly end on, so as to involve risk of collision, the helms of both shall be put to port, so that each may pass on the port side of the other.

Two Yachts crossing.—When two yachts are crossing so as to involve risk of collision, then if they have the wind on different sides, the yacht with the wind on the port side shall keep out of the way of the yacht with the wind on the starboard side, except in the case in which the yacht with the wind on the port side is close hauled, and the other yacht free, in which case the latter yacht shall keep out of the way; but if they have the wind on the same side, or if one of them has the wind aft, then the yacht which is to windward shall keep out of the way of the yacht which is to leeward.

Overtaking, rounding Marks, etc.—A yacht overtaking another yacht shall keep out of the way of the last-mentioned yacht, but when rounding any buoy or vessel used to mark out the course, should two yachts not be clear of each other at the time the leading yacht is close to, and actually rounding the mark, the outside yacht must give the other room to pass clear of it, whether it be the lee or weather yacht which is in danger of fouling the mark. No yacht to be considered clear, unless so much ahead as to give a free choice to the other on which side she will pass. An overtaking yacht shall not, however, be justified in attempting to establish an overlap and thus force a passage between the leading yacht and the mark, after the *latter yacht has* altered her helm for the purpose of rounding.

Obstructions to Sea room.—When passing a pier, shoal, rock, vessel, or other obstruction to sea room, should yachts not be clear of each other, the outside yacht or yachts must give room to the yacht in danger of fouling such obstruction, whether she be the weather or the leeward yacht; provided always that an overlap has been established before an obstruction is actually reached.

Luffing and bearing away.—A yacht may luff as she pleases to prevent another passing to windward, but must never bear away to hinder her passing to leeward—the lee side to be considered that on which the leading yacht of the two carries her main boom. The overtaking vessel, if to leeward, must not luff until she has drawn clear ahead of the yacht she has overtaken.

Close hauled approaching Shore.—If two yachts are standing towards a shore or shoal, or towards any buoy, boat, or vessel, and the yacht to leeward is likely to run aground, or foul of such buoy, boat, or vessel, and is not able to tack without coming into collision with the yacht to windward, the latter shall at once tack, on being hailed to do so by the owner of the leeward yacht, or the person acting as his representative, who shall be bound to see that his own vessel tacks at the same time.

Running Aground.—Any yacht running ashore, or foul of a buoy, vessel, or other obstruction, may use her own anchors, boats, warps, etc., to get off, but may not receive any assistance except from the crew of the vessel fouled. Any anchor, boat, or warp used must be taken on board again before she continues the race.

Fouling Yachts, Marks, etc.—Each yacht must go fairly round the course, and must not touch any buoy, boat, or vessel used to mark it out, but shall not be disqualified if wrongfully compelled to do so by another yacht. If a yacht, in consequence of her neglect of any of these rules, shall foul another yacht, or compel other yachts to foul, she shall forfeit all claim to the prize and shall pay all damages.

Sweeps.—No towing, sweeping, poling, or pushing, or any mode of propulsion except sails, shall be allowed.

Anchoring.—Yachts may anchor during a race, but must weigh their anchor again, and not slip. No yacht shall during a race make fast to any buoy, stage, or pier, or send an anchor out in a boat, except in case of running aground, or foul of any buoy, vessel, or other obstruction.

Sounding.—No other means of sounding than the lead and line allowed.

Man overboard.—In case of a man falling overboard from a competing yacht, all other yachts in a position to do so shall use their utmost endeavours to render assistance; and if it should appear that any yacht was prevented thereby winning the race, the committee shall have power to order it to be re-sailed.

The Yacht Racing Association further recommend for the consideration of Sailing Committees:—

Allowance to Schooners and Yawls.—That as mixed races are no satisfactory test of the relative speed of yachts, whenever possible, the different rigs should be kept separate; but when mixed races are unavoidable, the following rule shall be observed:—

The tonnage of schooners and yawls to be reckoned for time allowance as follows: viz. schooners at three-fifths and yawls at four-fifths of their actual tonnage. In calculating the deduction for difference of rig, the tonnage by certificate to the exact fraction to be used. In computing the time allowances from the result, $\frac{51}{94}$ and over to be considered a ton. Schooners and yawls to be allowed to enter in classes at the reduced tonnage.

That Flying Starts should be adopted when practicable, but no time should be allowed for delay in starting.

No Limit to Race.—That any limit to the time for concluding a race should be avoided as far as possible.

Courses.—That as distance is an important element in the calculation of time allowance, the marks and flag boats should be placed so as to mark as accurately as possible the length of the course, for which time is allowed.

Rounding Marks.—That in heavy weather it should be arranged, if practicable, for yachts to stay instead of jibe round marks.

ARRANGEMENTS FOR DISEMBARKING TROOPS BEFORE AN ENEMY.

To prepare the necessary orders, the following subjects must be considered and determined.

1. The number of troops to be first thrown on shore. This will depend not only on the amount of force present, and on that opposed to it, but on the number and capacity of suitable boats at command, and on the extent of the shore adapted for the disembarkation.

2. The number and classes of boats available and indispensable to receive troops, to land field guns, to carry guns to cover the operation, steamboats for towing, and ships to provide and man the boats. Also, the boats required for other consequent and simultaneous services; as for medical officers, horses, water for immediate use, and reserve ammunition. Each ship of war and transport should be required to furnish a list of her boats ready for service, and their dimensions.

3. The numerical succession of the boats to land the troops from the leader of the 1st division, as No. 1. Boats with guns are to be distinguished by letters. (See Instructions, page 314.)

4. The succession of troops from the right when landed; naming the corps, numbers, and the ships from which they are to be taken.*

5. The allotment of the troops to the boats; so that, except where boats with skirmishers intervene, boats as numbered may carry troops, in the succession they are to be arranged in on shore.* This is necessary to ensure their rapid formation, and to prevent disorder on the beach. The troops may then be landed simultaneously, or in succession from columns or single boats. In considering the sufficiency of the boats, the weight of each soldier with his rifle, ammunition, water and provisions for three days, may be estimated at 200 lbs. If horses are to be landed with an infantry regiment in due proportion for service in the field, from twelve to fifteen would be required for mounted officers, surgeon's stores, reserve ammunition, fodder for horses, and afterwards for the conveyance of sick, or footsore men.

* It is not absolutely necessary that the disposition of the troops in the boats should be such that the proper right of each battalion should retain its position when landed at the right, yet it is decidedly preferable that it should be so. For although with an inverted line all evolutions are practicable, yet it is better to avoid the inversion.

6. To avoid exposing and tiring the men unnecessarily, and losing time, precise arrangements should be made for rapidly and quietly placing the troops in the boats immediately the order is given. With this view a naval officer should ascertain and report how many accommodation ladders can be placed over the side of each ship having troops, for different boats to receive them from. He should arrange for having the ladders fixed in proper time, and for their being conspicuously and consecutively numbered from the foremost to the aftermost on each side, so that the boats to receive troops may be "told off" to the ladders. When more than one boat is "told off" to the same ladder, they are to go alongside according to the numerical succession in the order of rowing. To prevent delay, and to ensure the soldiers being landed in their relative positions, he should request that corresponding arrangements may be made on board by having at the appointed time such soldiers at the head of each ladder as are assigned to the boat which is to come alongside it. (See table of details, page 311.)

7. Each boat is to be provided with the gear and the other things named in the instructions. (See page 312.)

8. Decide on the place of rendezvous for the boats after receiving troops. Probably it would be at the ship nearest the landing-place.

9. Determine on the formation the boats are to assume at the rendezvous; on the officer to command the flotilla; on the leaders of divisions; how and by what they are to be towed.

10. Make the arrangements for flanking gunboats, or covering ships, and the positions they are to occupy; to do which, the neighbourhood of the place of disembarkation, both afloat and ashore, must be perfectly known or carefully examined, soundings obtained, and tides studied.

If the distances from the beach to conspicuous marks on shore in the direction of an expected enemy can be given to officers in the covering boats and covering ships, it will greatly assist them in determining their time fuzes and elevations, and may therefore materially affect the success of the operation.

11. Determine whether the skirmishers and their supports shall land without their valises, leaving them in the boats; if the rest of the landing party shall have their valises on when they get into the boats, but ready for slipping should the boat be much injured by shot; what clothing, cooked provisions, and water each man shall take; what spirits are to be taken with the troops, and to whom the spirits are to be given over; if the officers are to carry their own things, and officers' servants to be under arms. Rifles should never be loaded until the men land.

12. Arrange for boats to carry reserve ammunition, water (of which the supply must be abundant), provisions, medicines and stores, immediately the landing-place is secured. These duties are to be assigned to particular officers.

13. If necessary, arrange for future supply of provisions, stores, and ammunition from the ships, and for conveyance and reception of wounded men.

14. A beach master, assisted if necessary by other officers, should be appointed to control the work on the beach. Under them, a party of seamen should be stationed where the horses and stores are to be landed, with such well-stretched rope, slings, purchase and leading-blocks and spars for light shears, as the case may require.

15. If the landing is to be on an open and ample beach, the boats may probably best approach it in columns in line ahead, the columns being more or less numerous according to the number of boats employed. The fewer boats there are in a column, the less effect will ricochet shot have upon them; but a single line abreast would have a front much too great for the troops when landed, and increase the difficulty of finding a beach adequate for the purpose.

The distance between adjacent columns in feet should be the number of boats in a column multiplied by 20; so that when they are beached in line abreast, there may be about 10 feet between adjacent boats.

If the beach be insufficient for the whole force to land and form on at once, probably the disembarkation should be from columns in line abreast. This may enable the first line of troops to land and advance, and leave the beach clear for the second. Adjacent lines abreast for beaching should therefore be about a cable's length apart, as a battalion should disembark and form in two minutes in smooth water if the measures for disembarking have been well arranged, and the soldiers and sailors well instructed in the operation.

16. If the landing is to be from lines ahead, the skirmishers may be best placed in the first boat of each line; if from lines abreast, the extreme and centre boats; for being separated by equal intervals they may more readily cover the whole front of the troops.

The mode of landing, and the required disposition of the troops on shore, must be arranged by the military and naval officers in concert, that each department may work in accordance with the other.

The foregoing orders having been determined, the necessary orders may be prepared.

Outline of a Scheme of Instruction for the Disembarkation of a Force in the presence of an Enemy, to be issued by the Military and Naval Commanders in conjunction.

A copy of the instructions should be given to each officer commanding a corps, or detachment of a corps, and to the heads of military departments.

A copy to be given to each captain of a ship of war. He is to take care that the officers in charge of boats, or otherwise detached from the ship, have copies of the "tables," and such other parts of the instructions as they are concerned with, and that they perfectly understand the duties entrusted to them.

The captain of each transport should have a copy.

The instructions should be issued, if possible, before assembling in the neighbourhood of the place of disembarkation.

Instructions for Disembarking, etc.—The ships of war are to prepare the boats named in the annexed "table of details," and the boats are to be employed in the manner noted against their names in the table, and according to the following instructions:—

The ships from which troops are to be disembarked are to have accommodation ladders prepared for different boats to come alongside at the same time. The ladders are to be conspicuously numbered from the foremost on each side, as No. 1, to the aftermost as the highest number on the same side, so that the boats may readily find the ladders to which they are "told off." "A guess warp" is to be stretched alongside each ship's side for boats whilst loading, to ride by; and another rope is to be over the stern for loaded boats, waiting for others to proceed with them to the rendezvous. If horses or other weights have to be disembarked, the purchases in the transports should be rove, and everything prepared for expediting the work. (See pages 316, 317.)

Ships to indicate whether they are clear of troops or not by use of the ensigns or other symbols.

Each ship from which the troops first to be landed are to be taken, is to wear her ensign at the gaff or ensign staff until the last boat-load of such troops has left her, when she is immediately to hoist her ensign at the mizen topgallant masthead. Those transports which are entirely cleared of troops are to continue to wear the ensign at the mizen; but those

TABLE OF DETAILS

For Boats to be employed in Disembarking the Troops to be landed first.

Ships which are to provide Boats for landing.	Distinguishing No. and Class of Boat.		No. of Soldiers to each Boat.	No. and Name of Transport to which each Boat is to go.	Side and No. of Ladder to which each Boat is to go.	From what Corps Men are to be taken.	Where the Boats are to rendezvous after receiving the Troops.
.....	1	Launch	.....	No. ..... ( )	1, 3, 5, Starboard No. 1.	15th	Alongside. ..... there to form the order of Assembly.
	2	Launch	.....				
	3	Pinnace	.....		2, 4, Starboard No. 2.		
	4	Cutter	.....				
	5	Cutter	.....				
.....	6	Launch	.....	No. ..... ( )	6, 8, 10, Port No. 1.	60th	(See other table.)
	7	Launch	.....				
	8	Pinnace	.....		7, 9, Port No. 2.		
	9	Cutter	.....				
	10	Cutter	.....				
.....	11	Troop boat	.....	No. ..... ( )	11, 13, Starboard No. 1.	82nd	
	12	Troop boat	.....		12, 14, Port No. 1.		
	13	Troop boat	.....				
	14	Troop boat	.....				
.....	15	Troop boat	.....	No. ..... ( )	15, 17, Starboard No. 1.	23rd	
	16	Troop boat	.....		16, 18, Starboard No. 2.		
	17	Troop boat	.....				
	18	Troop boat	.....				

Special arrangements for towing the divisions of boats will be required, dependent on the number and nature of gun-vessels or steamboats available.

which have still troops to land, are to re-hoist their ensigns at the gaff when the flotilla has quitted the rendezvous for the beach. This must be attended to, to prevent boats returning in quest of remaining troops to empty vessels.

Preparation and fitting of boats.

Each boat is to have the means of stopping shot holes; several buckets for baling; two barécas of water, and drinking utensils for the use of people in the boats, and a small cask of water to be landed for the immediate use of the troops and horses; her anchor and cable, masts and sails, and two spare oars; but she is to be free from all unnecessary lumber. The sails are to be used to reduce labour only when the boats are not loaded with troops. A stout broad gangboard is to be fitted for each side of the bow, to hang about two feet below the gunwale, when fixed for landing. Whilst proceeding to the shore, the gangboards are to be hung along the outer sides of the boat, under the oars, with a line led from the after ends, also under the oars and inboard over the bows. When the boat is beached, the stops which hang the gangboards alongside are to be let go; the bowmen jumping on shore place their ends, and the foremost men in the boat pull the after ends forward and up by the line, and hang them by slings previously well adjusted.

As the gangboards may fail, or not give so free an exit to the men as is necessary, a grating or stage of plank about two feet wide is to be slung on each bow between the foremost rowlock and the stem, and to be level with the water when the boat has her complement of troops in her. Whilst going to the beach, these stages may be turned back close to the bows, and just before touching the beach, be thrown forward to hang horizontally in the slings. It would be impossible for troops (armed) to jump from a launch's gunwale, a height of nearly seven feet from the ground; but with that height divided by the stage, they can easily get over the bows. This is a most important fitting, for it may be of vital consequence that the men who have to seize the beach should not be detained under a fire they cannot return. The boats' crews should be exercised in placing these gangboards and stages, and if possible the troops in embarking and disembarking. This may be done with the boats on the ships' decks.

If the landing is to be on deep mud or deep sand, the boats which carry the field guns should be provided with plank or mess tables to run the field guns to the hard ground.

Each boat to land troops is to have her number, as shown in the numerical succession for the order of assembly, in white figures eight inches long, on a black ground, on both quarters and both bows; and the boats with guns are to have their distinguishing letter so placed.

Each boat is to have a boat's signal book, and an answering pendant, and a man conversant with the flags specially to look out for signals and to receive orders given by hailing. The boat of the officer commanding the flotilla, and of each officer commanding a division, is to have a set of boat's signal flags, a staff long enough to display four of the flags upon, and a light pole to spread the flags if it should be calm. Boat's signals.

If there is a probability of the boats being absent long after meal hours, the crews are to take a day's provisions cooked, and their spirits; and proper measures are to be taken to have the boats' crews relieved, for the boats may be required night and day. Boats' crews' meals, and the relief of boats' crews.

The officers in charge of boats and their crews should be made aware of the importance of not allowing their boats to be unnecessarily damaged, since injury to the boats may frustrate the intended service, or at any rate increase the difficulty of conducting it. Any injury done to boats is to be repaired at the earliest possible opportunity. Boats to be kept in repair.

The flotilla will be managed by the evolutions in the signal book, with which officers are presumed to be familiar, and by the signals appended to these instructions. The strictest attention must be paid to signals, and to keeping station. Flotilla to be managed by signal book and by signals appended.

The boats are to be alongside the transports, and at the ladders to which they are assigned in the table of details at .....o'clock, or when the signal is made. If more than one boat is assigned to the same ladder, they are to go alongside according to their numerical succession in the order of assembly. Having embarked the troops, the boats of the same ship of war coming from the same transports are proceeded to the rendezvous, where they are to form in (here state in what order of assembly) in accordance with the subjoined numerical succession and divisional arrangement, of which an example is shown in the following diagram. Time at which boats are to be at the respective transports and proceed to rendezvous.

Captain.....will command the flotilla. (He is to have three despatch boats in attendance.) Commander.....will lead the.....division; Commander.....will lead the..... division; (and so on). Officers of the flotilla.

A lieutenant is to be in the leading boat of the boats of each ship, even when that boat would have in her the officer commanding the division.

All officers appointed to boats of the flotilla are to be ready to go to the captain commanding it, to receive his instructions when the signal is made to do so.

Beach-master and his duties.

Commander.....is to be beach-master, assisted by Lieutenant.....and Lieutenant.....

He is to have a beach party of petty officers and seamen, a staff of signal men, and boats to carry messages. These men are to be taken from the ship to which he and the lieutenants belong.

He is to erect a signal staff in a convenient position, and have a set of signal flags and books with him. He is to cause a strict look-out to be kept

Distinguishing No. of Boat.	If in Columns in line ahead, the leading Boats are to contain Skirmishers and Supports.	Or, if in Columns in line abreast, Skirmishers and Supports are to be in the leading Columns.
1		
2	13 7 1	
3	14 8 2	6 5 4 3 2 1
4	15 9 3	
5		
6	16 10 4	
7	17 11 5	12 11 10 9 8 7
8	18 12 6	
9		
10	A B C D	18 17 16 15 14 13
11		
12	E F	
13		
14		
15	The distance between columns for beaching should be (in feet) No. of Boats multiplied by 20.	The distance between columns should be about a cable's length, so that the first line may land and advance before the second is landed.
16		
17		
18		

for signals afloat and on shore; and all ships are to keep a look-out for signals made from his signal station. He must, without loss of time, erect such shears or provide such means as may be proper for landing the heaviest weights which have to be brought on shore. The shears should be so placed that a boat drawing four feet water may come under them, or be "plumbed"

from their heads when sloped. Several pairs of shears may be required, and at different places. From the shears to hard ground, a road over which weights may be easily moved should, if necessary, be prepared. (If the disembarkation be on a large scale, see page 323.)

The disembarkation will be conducted as directed under the signal to "beach the boats and disembark." (See page 317.)

If the skirmishers, or any other of the troops are to leave their valises in the boats, the crews are to land the valises, and stack them as near the beach as they can be properly placed, and leave them there with the soldiers appointed to take charge of them.

Boats to succour troop-boats disabled by shot.

The following boats, viz.:.....are to form a line abreast two cables astern of the boats, with troops, as at A, B, C, D, ready to go to the succour of any disabled boats, and to land their troops.

Boats for medical officers.

The medical officers are to be in boats with necessary attendants, stores, and appliances, at three cables' length distance from the flotilla, as at E, F.

Landing casks of water.

The casks of water brought for the troops are to be placed clear of surf and tide, with bungs up; if the sun be powerful, they should be in shade or covered in sand, to prevent leakage.

Details respecting the troops. Getting into boats.

At the time stated for the boats to be alongside the transports, the troops, as indicated in the table of details, are to be at their respective gangways, and immediately to go into the boats. They are to be placed in the boats from forward to aft as they are to be ranged from right to left on shore. They are to be cautioned not to stand up in the boats, and not to make a noise. Sidesmen are to be stationed at the ladders to pass rifles into the boats, and assist the soldiers.

Before quitting the ships, the skirmishers and their supports should be "told off," and if possible the officers and men comprising these parties should have the ground pointed out to them for which they are to push after leaving the boats. They should have their valises off whilst in the boats, and leave them in the boats, that they may spring instantly on shore and advance. The valises will be landed by the boat's crew, stacked on the beach, and left in charge of the rear-guard. The skirmishers will return for them when the landing has been made good.

The rest of the troops are to have their valises on, and to land with them on; but whilst in the boats they are to keep them unbuckled, ready for

slipping in case the boats be much injured by shot. In no case are the troops to load whilst in the boats.

The troops first landed should have trenching tools with them, as it may be necessary at once to render buildings defensible, or to throw up cover.

A second table of details to be provided if all the troops cannot be landed at once.

If all the troops cannot be landed at once, a second table of details should be filled in for the guidance of the officers commanding the boats, after the first party has been landed, and for military officers on board each transport.

The guns, reserve ammunition, projectiles, provisions, medicines, stores, and water, if necessary, which are to be next landed must be ready for leaving the ships as soon as the beach is secured.

As many horse slings must be ready as are equal to one quarter the number of horses, unless it should be necessary to hoist the horses out of the boats on shore, as well as out of the ships, in which case a few more would be wanted. Slings for hoisting out field guns and ammunition waggons should be in such numbers that there shall be no waiting for them.

Topsides of transports should be so cleared away under lower yards or derricks, that little hoisting may be required to get guns and heavy weights over. All the appliances for each battery of artillery should be mustered, and things so disposed of and lists taken that each may leave the ship complete.

Whilst the transports are being cleared, proper military officers should be on board to determine in what succession the things are to be despatched, and to see that expedition and care are used in sending them.

In each transport the duties and stations of the soldiers and crew for clearing her should be reduced to writing, and every officer and man made to understand clearly what he has to do to expedite the disembarkation.

The naval duties relating to clearing transports of guns and stores, is assigned to Captain..... The boats carrying these things are to have distinguishing flags preconcerted with the chief of the military staff and beach-master, so that the department to which they are consigned may readily find them.

Landing horses from ships' boats on a beach.

When horses are to be landed from ships' boats, it may be the best plan to place the boats' sterns on the beach, and to have inclined planes from inboard to the sterns, and other inclined planes from the sterns to the shore. For those boats *which, having* landed infantry, are to land horses, the inclined planes should

be previously carefully fitted; their component pieces all marked, and men taught to put them rapidly together, so that the boats as they return from one service may be quickly prepared for the other. The outboard plane may be made of mess tables supported by studding-sail yards and booms cut to the required length, and sufficiently numerous to have the plane sustained at very short spaces. The boats should be prepared with dunnage. If a pier of a convenient height can be found, or formed, the horses may walk to it from the boats so fitted. Before sending horses and heavy weights from the ships, care must be taken that the means exist on shore of landing them with safety.

Captains of H. M. ships to communicate with military officers with whom they have to act.

The captains of H. M. ships should, without loss of time, place themselves in communication personally, or otherwise, with the commanding officers of troops, the chiefs of military departments, and with the captains of transports with whom they have to act, so that a complete understanding may exist between all branches of the service with regard to the duties which they are jointly to carry into effect.

This order to be signed by military and naval commanders.

Signal to be used when the boats are close to the beach on which the landing is to be.

SIGNAL No. .

Beach the Boats and Disembark.

With a Cornet Under. | **With a Cornet Over.**

Execution.

If from lines ahead.

Each boat is to be beached ten feet clear of, and on the starboard side of the boat preceding it. | Each boat is to be beached ten feet clear of, and on the port side of the boat preceding it.

Each leader is to preserve exactly the boat's proper distance from the next leader in the direction of the front.

The second boat of each column is to sheer twenty feet out of the wake of her leader, on the side indicated by the position of the cornet, and preserve her proper distance from the leader. She will be steered with sufficient accuracy if her gunwale at her broadest part be kept "on with" the outer ends of the oars of the leader.—Each following boat of every column is to act in the same way with regard to her next ahead, as the second boat does with the leader.

If from a single line abreast.

The boats are to be beached at the distance apart at which they are then arranged.

If from lines abreast.

Each boat in the 2nd, 3rd, 4th, 5th, or 6th column is to be beached ten feet clear of, and on the starboard side of her corresponding boat in the column preceding it.

Each boat in the 2nd, 3rd, 4th, 5th, or 6th column is to be beached ten feet clear of, and on the port side of her corresponding boat in the column preceding it.

The leader of each succeeding column is to adjust accordingly the position of his column with regard to the one preceding it.

If in two lines, the boats of each column must be forty feet apart; if in three, sixty feet apart.

Note.—When the preparative is made with this signal, the bow men are to lay their oars in and prepare gangboards and other appliances for landing the troops. The anchor is to be got ready at the stern and the cable seen clear. On the inner end of the cable there is to be a buoy, that it may be slipped if the anchor should have been let go too soon. As soon as the boats touch the beach, their cables are to be set taut and oars to be got ready to keep the boat end on.

SIGNAL No. .

Boats are prepared to Re-embark Troops.

If the boats have been beached from lines ahead and are lying in line abreast on the beach in numerical succession.

Execution.

If special orders to the contrary have not been given, the following instructions are to be followed:—

The troops as they arrive on the beach, and as they stand in the ranks, are to be embarked, the boats being taken in the numerical succession as they are ranged on the beach. Officers are to be appointed by the beach-master to show them the boats they are to occupy, and to direct how many men each boat is to contain.

The boats are to be prepared with gangboards and for being kept afloat by being pulled and pushed out as the troops get into them. If the heavy boats cannot otherwise be kept afloat, gangways are to be prepared over the light boats. Particular boats are to be ready to embark field guns with rapidity. If necessary, arrangements are to be made for boats when full of troops to proceed to co-operate by rifle fire with the covering gunboats on the flanks, so as to facilitate the withdrawal of the other men and the last boats. Such boats must be cautioned not to mask the fire of any boats employed for the same purpose.

Particular boats are to be prepared for wounded men, and when *full* are to quit the beach.

If the boats have been beached from two, three, or four lines abreast.

The troops as they arrive on the beach, and as they stand in the ranks, are to be embarked in the boats of the 1st division in their numerical succession, omitting, till the boats of the 1st

division are full, all the boats of the 2nd division and 3rd division, which will be intermixed with the 1st division. When the boats of the 1st division are full, those of the 2nd division and 3rd division are successively to be filled in the same way. Officers are to be appointed by the beach-master to show the troops the boats they are to go into, and to direct how many men each is to contain.

The other directions under the first case apply to this.

SIGNAL No. .

The boats about to embark troops, or those of the division or ship indicated, are, on receiving their complement of troops or material, to leave the beach, and form the order denoted.

SIGNAL No. .

The boats about to embark troops, or those of the division or ship indicated, are, on receiving their complement of troops or material, to leave the beach, and proceed to their ships or on the duty ordered.

If the disembarkation is to be on a very great scale, the following matters must be determined upon in addition to those already mentioned.

If the disembarkation is on a great scale.

It may be assumed that a fleet containing a great expeditionary force would rendezvous previous to proceeding to the place of disembarkation. At the rendezvous every detail should be settled that the least possible time may elapse between the arrival of the expedition at its destination, and the disembarkation.

The army and the transports should be "told off" in corresponding divisions; ships of war attached to each division to conduct it; the rest of the fleet being as little crowded as possible, organized as a distinct formation for the protection of the whole.

The ships of each division of transports should be distinguished by wearing under the convoy flag, 1, 2, or 3, to denote that they contain troops of the 1st, 2nd, or 3rd division of the army.

Transports, how to be distinguished.

Each transport should have special distinguishing pendants assigned to her, to be shown with her divisional distinguishing signal when she alone is addressed, or referred to.

The order of sailing for the transports, as well as for the ships of war, must be promulgated, and the necessity for a strict attention to station-keeping enforced.

Order of sailing and scheme for anchoring to be issued.

A scheme for anchoring at the destination must also be issued, and

transports required to have all cables bent, and warps, and boats for laying the warps out, ready for instant use.

All ships should leave the rendezvous with storm-sails bent, and with the baggage, guns, and horses well secured, in case of bad weather.

Precautions against an attack at sea.

If there is the least prospect of being attacked at sea, that greatest of dangers to a large combined expedition, every ship of war should be absolutely clear for action; at least one watch's hammocks stowed, and the watch at their guns. Arrangements should be made for look-out vessels to encircle the fleet, and night alarm signals established. Before leaving the rendezvous, it may be well to ascertain by signals, repeated by a chain of ships, extending over twenty-five miles, if the neighbourhood is clear of enemy's vessels.

Small vessels to precede and buoy dangers, etc., near intended anchorage.

Small vessels should be selected to precede the fleet a little, and anchor where it may be necessary to indicate dangers, to sound and buoy shoals. This also may be done somewhat sooner, as a feint on some other part of the enemy's coast than that intended to land on.

If possible, the time of arriving at the rendezvous, and the time spent at it, should, if possible, be so adjusted that there may be a good moon for making the passage.

Hospital ship to be provided.

If no hospital ship has been provided, it should be determined at the rendezvous which transport when clear of troops can be best converted into one. Arrangements should be concerted for preparing her without delay for the reception of sick and wounded men, and attaching medical officers and medical stores to her.

At the rendezvous the expedition should be freed from officers and men who, from illness, have not a prospect of being soon equal to work. The same rule should be applied to horses.

Additional boats to be procured.

As the usual establishment of boats of a ship of the line will not carry more than 300 men in heavy marching order, before a disembarkation on a great scale could take place many additional boats must be procured. As each accoutred infantry soldier weighs about 200 lbs., as each horse occupies about 9 ft. and weighs about 10 cwt., and as the weight and dimensions of the guns, ammunition, and accompaniments of a battery of artillery are known, and as the amount of each of the "arms" which are to be simultaneously landed must be decided, the required boat accommodation may be calculated This is the least boat tonnage that will suffice, for after the landing-place is secured, the rest of

the troops, the military train, guns, stores, camp equipage, etc., must be sent on shore, whilst probably there will be demands for boats to remove wounded and sick men.

It may be assumed that each large ship of war, by fitting davits along her sides, by placing boats inside her present boom boats, and others within each other on the quarter-deck, might carry boats equal to receiving 600 men, and these boats might be all hoisted out or lowered down in half an hour.

Greatly increased accommodation could be provided if collapsible boats were supplied to the expedition.

Preparation of boats, flats, etc.

The boats for landing infantry must be provided with oars, anchors, cables, painters, and the bow fittings as recommended for launches (see p. 312). Others, besides being so prepared, must also have portable but secure decks for artillery and cavalry. If it be impossible to procure boats which, taken singly, are wide enough to place horses and guns upon, flats or rafts may be made of two boats. They should be secured together by lashings from bow and stern, and by athwartship lashings. Beams strong and numerous enough for the proposed work must be placed athwart both, and be secured to each to carry the deck or planking. Round the deck there must be strong stanchions and ropes. These flats should be steered by oars.

It will be a great convenience that these flats when loaded should float about the same height as the pier at which they are to land, so that horses may step from one to the other, and things be transferred without a necessity for hoisting; and this should also be borne in mind when constructing the pier.

Construction of jetties or piers.

Some flat-bottomed broad boats may be required for forming piers; these must be decked over from gunwale to gunwale, and planks to form a brow to the shore, must be provided. A plan of the intended pier should be formed: indeed, it might be advantageous to put the pier itself together, that no necessary appliance or fitting may be overlooked. When the horse, gun, and pier boats have been fitted, carpenters and others should be instructed in putting the fittings rapidly in place, and the fittings should be all marked and stowed ready for instant use. The boats must be assigned to different ships to take care of, and to officer and man.

When flat-bottomed boats or suitable country craft cannot be procured, a jetty may be speedily constructed from a ship's resources by one of the following plans:—

1st. The outer end of the jetty may rest on ships' iron tanks sunk as a standing buttress, and, if necessary, filled with stones, sand and water, to render them stable. Between the outer end of the jetty and the shore there may be other buttresses, made probably of shallower tanks; the spaces between the clusters of tanks and the shore must be bridged over by spars and plank. Mess tables and stools may be used for the purpose. If the depth of water be greater than the height of a tank, a riding tier of tanks may be added. In this case the lower tier should be placed on a raft, well secured to it and to each other, towed into position, and sunk.

2nd. If the ground be very uneven, the outer end of the jetty may be on as many empty floating tanks as will give the required buoyancy. They must be placed on a raft, be well secured to it, lashed together, and the lashings set taut by wedges between the tanks. The raft must be towed into its position and there secured by several anchors and hawsers, and by quarter guys to the shore. The inner end must not be so rigidly secured that it will not admit of the undulating of the outer end by any trifling swell or by variations of weights that may be upon it.

3rd. Should the features of the shore or other circumstances render it desirable, both ends of the pier may be on floating tanks, and be supported intermediately by other tanks. The inner end may be connected with the shore by a "brow," or the weights may be lifted from it by derrick or shears. The outer end must be kept in position by quarter guys, anchors, and hawsers. It may be convenient that the hawsers should be "single whips," rove through blocks at the rings of the anchors, the standing parts being made fast to the raft, and the hauling parts taken on shore.

To prevent such a floating pier inclining too much by wind, or by weights placed on one side, spars may be secured under and athwart the floating tanks, projecting several feet on each side, with one or more empty tanks at each extremity. The immersion of the tank on one side, and weight of that on the other, would both resist any tendency of the jetty to incline. Pumps should be fitted to the floating pier.

Management of a large number of boats.

For the ready management of a vast number of boats, it would be desirable to have them in separate flotillas, which, although acting, if necessary, in concert, should have distinct formations, and have their details managed by their respective commanding officer. The officers should be assigned to the flotillas, and the boats be properly prepared as stated before, so as to be ready to proceed on service immediately the expedition arrives at its destination.

Each boat of the different flotillas should have below the figure on her

bows and quarters showing the number of her numerical succession in her own flotilla, a horizontal line and the number of the flotilla to which she is attached, as

1	2 etc.;	1	2 etc.;	1	2 etc.
1	1	2	2	3	3

When one of these flotillas, or a part of it, as a division or the boats of a ship, is addressed, it will be by the letter B (according to the boat's signal book) under the numeral flag indicative of the particular flotilla; combined (in the case of a part being addressed) with the appropriate flag.

To conduct the disembarkation, a table of details would be required for each flotilla; and second tables if it had to land a second part of troops, all of which should be arranged before quitting the rendezvous.

When the boats are organized in separate flotillas, the whole of them may be applied to landing one entire division at a time, or, if equal to it, they may land divisions simultaneously; or the first or advanced line of several divisions may be landed together. It should be determined whilst at the rendezvous how the boats are to be applied.

It must be decided at the rendezvous if the landing of the cavalry and artillery is to be proceeded with at the same time as that of the infantry.

As the boats with horses and guns must be towed, and will be slower than the boats which are not towed, it might be well that each flotilla to land cavalry and artillery, should have a supplementary squadron of boats for the purpose. These boats should not be formed with the other boats or they may be exposed and detained longer than necessary under an unreturned fire. If the artillery and cavalry are to be landed after the infantry, as would usually be the case, the boats which landed the infantry should be previously "told off" to different transports to return to tow boats with guns and horses. The boats with cavalry and artillery must not be overloaded, and as many of their oars as possible are to be used.

Beach-master's duties.

In addition to the duties already named for the guidance of the beach-master (at pages 314 and 321), he is, when the disembarkation is on a great scale, to ascertain from the chief of the military staff, with what officers he is to communicate on the beach respecting the landing of guns, ammunition, shot, stores, medical stores, water, provisions, etc., and in whose charge these things are to be left.

As far as the strength of his party will permit, he is to place the things

landed in the most convenient position, and to cause due care to be taken of them.

He is to inform the military departments with whom he is to co-operate how the boats landing things for them will be distinguished, and where they will be found.

He is to communicate also with the naval officer charged with taking the before-mentioned things from the ships to the shore; and he is, during the operations, to keep up such communications by signal as events may render necessary.

He is to expedite the business on the beach, and to prevent any loitering or delay in the boats, or on the part of officers or men of the ships; and if necessary, he is to point out to the proper military officers that the beach should be kept clear of all unnecessary people. Should he, on any emergency, require more strength than his party afford him, he should apply for the temporary aid of a fatigue party, or sentries, from the senior military officer near him.

The beach-master is to take care that the piers, jetties, sheers, and all appliances for disembarking troops, horses, guns, and stores, are kept in good order, and he is, without loss of time, to apply for such artificers as he may require, to repair any damage that may interfere with the perfect working condition of his department.

Reserve ammunition, stores, intrenching tools, etc.

The reserve ammunition, intrenching tools, stores, and forage for each division of the army must be assigned, and arrangements made for their being landed conveniently for their respective divisions; (see previous remarks on boats carrying these things having distinguishing flags, page 316).

Preparation of land transport.

The animals, and other means of land transport, should be sought or determined at the rendezvous, and its power estimated, that it may be determined to what purpose it is to be applied; observing that reserve ammunition, provisions, surgeon's instruments, medicine, and money chests must have the preference.

At the place of disembarkation how ships containing infantry, cavalry, artillery stores, etc., are to be distinguished from each other.

At the place of disembarkation, all ships, whether ships of war, or transports which have on board infantry who are to be disembarked, are to have the number or numbers of the regiment or regiments, and the letter R in characters two feet long on a board hung over the stern, and on a board hung in each main rigging.

Ships having cavalry are to have a letter C with the number of the regiment in the three places before named.

Ships having ammunition to be landed, are to have the word "Ammunition" in red characters, two feet long, on a board hung over the stern, and on a board in each main rigging.

Ships having stores to land, are to have the word "Stores" in black characters as before stated.

Every ship as soon as perfectly cleared, is to have the boards removed.

(The ships will prepare accordingly.)

Arrangements made for re-embarking.

Arrange for a retreat by having piers constructed and boats held ready, so that there may be a speedy re-embarkation. (See signals appended.)

Details.

Every detail that it is possible to determine should be settled before leaving the rendezvous.

The troops to be "told off" in divisions, and the transports in corresponding divisions.

Order of sailing for transports, and "order of anchorage."

Ships of war prepared for defence. Circumspection in quitting the anchorage. Distinguishing signals for transports. Ships to be prepared for bad weather. Arrangements for hospital ships.

In what succession the infantry, cavalry, artillery, reserve ammunition, shot, provisions, stores, and camp equipage are to be landed.

The procuring and preparation of boats. The composition of the flotillas of boats. The allotment of troops to boats, and their preparation for going into them.

The troops to be first thrown on shore, and their succession from the right to left.

Skirmishers, their valises, and cooked provisions. What things officers are to take. The order of assembly.

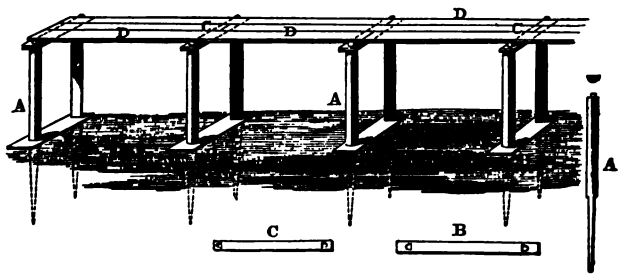
The arrangements for towing the various divisions, and detailing each steamboat for her particular duty.

The ships and boats, with guns to cover the landing.

Boats to land horses, guns, stores, reserve ammunition, etc.

The number and the numbering of the accommodation ladders of transports. Preparation of transports for rapid disembarkation. Beach-masters and beach party of seamen and soldiers. Construction of piers, shears, etc. Means of land transport, and how to be applied. Orders for disembarkation prepared and issued.

Sketch of a Flying Pier used by Admiral Sir James Hope during the War in China, 1860.



A—Pile, formed of a split spar of 6 in. diameter, 5 ft. above, and 4 ft. below ground, with point hardened by fire, and head bound with iron to prevent splitting in driving.

B—Lower cross plank, about 7 ft. long.
C—Upper cross plank, about 6 ft. long.
} Same breadth and thickness as an ordinary deal, holes for the piles to be horse-shoe shaped, round side out.

D—Flooring planks, about 14 ft. long, laid so as not to bring two joints alongside each other.

This pier can only be used over mud.

The breadth may be increased as required, by placing two or more piers alongside each other.

By doubling the planks in the wake of the wheels, this kind of pier will bear the weight of light artillery.

SECTION VII.

ROCKET AND MORTAR APPARATUS FOR SAVING LIFE FROM SHIPWRECK — LIFEBOATS — LIFE BUOYS — LIFE BELTS— HINTS TO BATHERS—INSTRUCTIONS FOR RESTORING THE APPARENTLY DROWNED—FIRST HELP IN ACCIDENTS— MEDICAL AND SURGICAL HINTS—COOKERY—WATER— DISINFECTION.

SAVING LIFE FROM SHIPWRECK.

Board of Trade Instructions in respect of the Rocket and Mortar Apparatus.

IT is unnecessary to describe minutely the manner in which the Rocket Apparatus is to be arranged for firing, as a knowledge thereof, and of the manner of using the apparatus, can only be obtained by actual practice. It may, however, be observed that an angle of 45° for the mortar, and 35° to 38° for Boxer's Rocket, are the elevations which appear to give the greatest range. The first shot or rocket should always be fired with the rocket line in the box, and the box should be slightly tilted towards the wreck. But for subsequent shots the line may be faked on the beach, care being taken that no impediments are in the way of its running out rapidly when the rocket or shot is fired.

Great care should be taken in arranging the apparatus with precision for firing the first shot or rocket, as after the line becomes wetted and dirty the chances of effecting a communication are more remote.

The rocket line should be fastened to the rocket stick. The line should also have a knot made near the hole at the end of the rocket staff, so that if the line is burnt near the rocket the knot will catch the stick.

When the line has been thrown over the ship, and has been grappled by the crew, a signal will be made in the following manner:—

If in the daytime, one of the crew, for this purpose separated from the rest, will wave his hat or his hand, or a flag or handkerchief: or (if at night) a rocket, a blue light, or a gun will be fired, or a light shown over the ship's gunwale for a short time, and will then be concealed.

On this signal being seen on shore, the inshore end of the shot or rocket line should be made fast to the whip, *by being bent round both parts of it* at about two fathoms from the tailed block, and a signal should then be made as follows, for those on the wreck to haul off the line:—

One of the men on shore is to be separated from the rest, and in the daytime is to wave a small red flag, or at night is to show a red light for about a minute, and then again conceal it.

The crew of the wreck on seeing this signal will haul on the shot or rocket line till they get the whip and tailed block, when they will make the

tail of the block fast to the mast, *as high up as circumstances will permit*, or to the HIGHEST secure part of the vessel, and will cast off the rocket line, and make the signal as before for those on shore to haul off the hawser.

As soon as the signal is perceived by those on shore, the whip (being previously made fast to the hawser at two or three fathoms from its end) will be manned, and the hawser hauled off by it to the wreck, by those on shore.

As soon as the persons on the wreck get hold of the hawser, they will proceed to *make it fast to the wreck at about eighteen inches ABOVE the place where the tail of the block is fixed;* and when they have secured it, and disconnected the hawser from the whip, they will signal as before to the people on shore.

On perceiving this signal, the hawser is to be set up by means of the double block tackle purchase; and the breeches buoy (the block of which will have been adjusted on the hawser) is to have the whip secured to it by a clove hitch; and, by means of the whip, is to be hauled off to the wreck by those stationed for the purpose on the shore; who, also, on the next signal being shown, implying that a person is secured in the sling, will haul him ashore, and repeat the operation to and fro until all are landed. The parts of the whip line should be kept as far apart as possible.

Circumstances may require some deviation from the above rule. For instance, if the wrecked vessel be subjected to violent motion by the beat of the sea, it will be better not to set up the hawser at all, but to man it with as many hands as can be spared, and reeve it over a triangle, if necessary, when by hauling and veering on it, following the motion of the vessel, a sufficiently uniform strain on it would be obtained without the risk of carrying it away.

Again, circumstances might arise, as they have sometimes done, when the immediate breaking up of the wreck might be imminent, and the delay in getting the hawser on board be of serious moment. In such a case the floating sling buoy should be hauled off by the whip alone, and the wrecked persons brought ashore in it floating in the water.

And again; in cases where the wreck happens on a flat shore, the hawser need not be set up at all, but the whip made to answer for both hawser and whip. When this is the case, the travelling block should be taken from the sling life buoy, and one end of the whip should be run through the thimble attached to the life buoy slings. The ends of the whip should then be made fast to the grummets on the sides of the life buoy.

In all other cases the hawser should be set up when practicable.

List of the Lifeboat Stations of the Royal National Lifeboat Institution.

ENGLAND.

Northumberland—
Berwick-on-Tweed.
Holy Island—No. 1.
" No. 2.
North Sunderland.
Boulmer.
Alnmouth.
Hauxley.
Cresswell.
Newbiggin.
Blyth—No. 1.
" No. 2.
Cullercoats.
Tynemouth—No. 1.
" No. 2.

Durham—
Whitburn.
Sunderland—No. 1.
" No. 2.
" No. 3.
" No. 4.
Seaham.
Hartlepool—No. 1.
" No. 2.
" No. 3.
West Hartlepool, No. 1.
West Hartlepool, No. 2.
Seaton Carew.

Yorkshire—
Middlesborough.
Redcar.
Saltburn.
Staithes.
Runswick.
Upgang.
Whitby—No. 1.
" No. 2.
Scarborough.
Filey.
Flamborough, No. 1.
" No. 2.

Yorkshire—*continued.*
Bridlington.
Hornsea.
Withernsea.

Lincoln—
Cleethorpes.
Donna Nook.
Theddlethorpe.
Sutton.
Chapel.
Skegness.

Norfolk—
Hunstanton.
Brancaster.
Wells.
Blakeney.
Sheringham.
Cromer.
Mundesley.
Bacton.
Hasborough.
Palling—No. 1.
" No. 2.
Winterton—No. 1.
" No. 2.
Caister—No. 1.
" No. 2.
Yarmouth—No. 1.
" No. 2.

Suffolk—
Gorleston.
Lowestoft—No. 1.
" No. 2.
Pakefield—No. 1.
" No. 2.
Kessingland—No. 1.
" No. 2.
Southwold—No. 1.
" No. 2.
Dunwich.
Thorpeness.
Aldborough.

Essex—
Harwich.
Clacton-on-Sea.
Southend.

Kent—
Margate.
Kingsgate.
Broadstairs.
Ramsgate.
North Deal.
Walmer.
Kingsdowne.
Dover.
Hythe.
New Romney.
Dungeness.

Sussex—
Rye.
Winchelsea.
Hastings.
Eastbourne.
Newhaven.
Brighton.
Shoreham.
Worthing.
Selsey.
Chichester Harbour.

Hampshire—
Hayling Island.

Isle of Wight—
Bembridge.
Brighstone Grange.
Brooke.

Alderney—
St. Anne.

Guernsey—
St. Samson's.

Dorset—
Poole.
Swanage.

Dorset—*continued.*
Kimeridge.
Weymouth.
Lyme Regis.

South Devon—
Sidmouth.
Exmouth.
Teignmouth.
Torquay.
Brixham.
Dartmouth.
Salcombe.
Hope Cove.
Yealm Mouth.
Plymouth.

Cornwall—
Looe.
Fowey.
Mevagissey.
Portloe.
Falmouth.
Porthoustock.
Cadgwith.
Lizard.
Mullion.
Porthleven.
Pensance.
Sennen Cove
Scilly Isles.
St. Ives.
Hayle.
New Quay.
Padstow.
Port Isaac.
Bude Haven.

North Devon—
Clovelly.
Appledore—No. 1.
" No. 2.
Braunton.
Morte Bay.
Ilfracombe.
Lynmouth.

England—*continued.*

Somerset—
Watchet.
Burnham.

Cheshire—
New Brighton—
No. 1.
Do. (Tubular) No. 2.

Lancashire—
Southport.
Lytham.
Blackpool.
Fleetwood.
Piel.

Isle of Man—
Castletown.
Douglas—No. 1.
,, No. 2.
Ramsey.

Cumberland—
Seascale.
Whitehaven.
Maryport.
Silloth.

WALES.

Glamorganshire—
Penarth.
Porthcawl.
Swansea.

Carmarthenshire—
Pembrey.
Carmarthen Bay.

Pembrokeshire—
Tenby.
Milford.
Solva.
St. David's.
Fishguard—No. 1.
,, No. 2.

Cardiganshire—
Cardigan.
New Quay.
Aberystwith.

Merionethshire—
Aberdovey.
Barmouth.

Carnarvonshire—
Portmadoc.
Abersoch.
Porthdinllaen.
Orme's Head.

Anglesey—
Llanddwyn.
Rhosneigir.
Rhoscolyn.
Holyhead.
Cemlyn.
Cemaes.
Bull Bay.
Moelfre.
Penmon.

Denbighshire—
Llanddulas.

Flintshire—
Rhyl—No. 1.
Do. (Tubular) No. 2.

SCOTLAND.

Kirkcudbright—
Kirkcudbright.

Wigton—
Whithorn.
Port Logan.
Port Patrick.

Ayrshire—
Ballantrae.
Girvan.
Ayr.
Troon.
Irvine.
Ardrossan.

Isle of Arran—
Kildonan.

Argyllshire—
Campbeltown.
Southend.

Orkney Islands—
Stromness.
Longhope.

Caithness-shire—
Huna.
Thurso.
Ackergill.

Nairnshire—
Nairn.

Elginshire—
Lossiemouth.

Banffshire—
Buckie.
Banff.

Aberdeenshire—
Fraserburgh.
Whitelink Bay.
Peterhead.
Cruden.
Newburgh.

Kincardineshire—
Stonehaven.
Gourdon.

Forfar—
Montrose—No. 1.
,, No. 2.
Arbroath.
Buddon Ness and Broughty Ferry (Dundee).

Fifeshire—
St. Andrew's.
Anstruther.

Haddingtonshire—
North Berwick.
Dunbar.

Berwickshire—
Eyemouth.

IRELAND.

Co. Londonderry—
Greencastle.

Antrim—
Portrush.

Down—
Groomsport.
Ballywalter.
Tyrella.
Newcastle (Dundrum Bay).

Louth—
Dundalk—
1, Giles' Quay.
2, Blackrock.
Drogheda—No. 1.
,, No. 2.

Dublin—
Balbriggan.
Skerries.
Rogerstown.
Howth.
Poolbeg.
Kingstown.

Wicklow—
Greystones.
Wicklow.
Arklow.

Wexford—
Courtown.
Cahore.
Wexford—No. 1.
,, No. 2.
Carnsore.
Duncannon.

Waterford—
Tramore.
Dungarvan.
Ardmore.

Cork—
Youghal.
Ballycotton.
Queenstown.
Courtmacsherry.

Kerry—
Valentia.
Tralee Bay.

LIFEBOATS.

THE lifeboats adopted for general service by the National Lifeboat Institution are thirty-three feet in length and eight feet in breadth. They possess in the highest degree all the qualities which it is desirable that a lifeboat should possess:—(1) Great lateral stability, or resistance to upsetting. (2) Speed against a heavy sea. (3) Facility for launching and taking the shore. (4) Immediate self-discharge of any water breaking into her. (5) The important advantage of self-righting if upset. (6) Strength. (7) Stowage room for a large number of passengers.

LIFE BUOYS.

THE life buoys at present in common use in the navy are the Service Life Buoy and the Circular Cork Life Buoy (Kisbie's). The latter is also in general use in the mercantile marine.

There are usually some others on trial, one of the latest of these is the Whitby Life Buoy, which is circular, made of metal in watertight compartments, and fitted with a righting apparatus at each side.

The Service Life Buoy is supposed to be capable of keeping four men afloat. It is fitted with the calcium light, which burns from forty minutes to an hour, for the purpose of denoting its position; by the smoke by day, and light at night.

Great coolness and caution is requisite to float this buoy. As soon as you get hold, place your feet on the balancing plate, grasping the pole with your hands. In this position you will float with your head well above water. Some men get frightened, and endeavour to raise themselves higher up the buoy, which is certain to overbalance it, and throw them headlong into the water again.

Kisbie's Life Buoy of the ordinary circular form and size will support two men holding on outside. The best position for one man to keep himself afloat is to slip the buoy over his head, and rest his arms over it on either side. These buoys are sometimes stuffed with rushes instead of cork, and should the outside covering not be perfectly watertight they soon get sodden and lose much of their buoyancy.

For night work a calcium light is sometimes attached to them by a lanyard.

LIFE BELTS.

THE life belts supplied to men-of-war are warranted, after twenty-four hours' immersion, to support twenty-three pounds of iron.

When stowed away, the upper or shoulder strings should be ready tied in a half-bow, so that it can be put quickly over the head without untying; the head should be put through the centre opening, and the arms through the side openings; the lower or waist-strings are then brought round from behind and tied in front. The shoulder-strings cross behind like trouser-braces; they should be drawn tightly over the shoulders, so as to keep the belts close up under the arms, and being tied close to the breast-corks in front, they can be readily pulled up tighter and retied at pleasure,—they will not interfere with the free use of the arms, either in rowing or swimming.

TO BATHERS.

Hints issued by the Royal Humane Society.

AVOID bathing within *two* hours after a meal. Avoid bathing when exhausted by fatigue or from any other cause. Avoid bathing when the body is cooling after perspiration. Avoid bathing altogether in the open air if, after having been a short time in the water, there is a sense of chilliness with numbness of the hands and feet; but bathe when the body is warm, provided no time is lost in getting into the water.

Avoid chilling the body by sitting or standing *undressed* on the banks or in the boats after having been in the water.

Avoid remaining too long in the water—leave the water immediately there is the slightest feeling of chilliness.

The vigorous and strong may bathe early in the morning on an empty stomach. The young, and those who are weak, had better bathe two or three hours after a meal—the best time for such is from two to three hours after breakfast.

Those who are subject to attacks of giddiness or faintness, and those who suffer from palpitation and other sense of discomfort at the heart, should not bathe without first consulting their medical adviser.

All that is necessary to keep a person from drowning in deep water, is to

keep the water out of the lungs. Suppose yourself a bottle—your nose is the nozzle of the bottle, and must be kept out of the water; if it goes under, don't breathe at all till it comes out; then, to prevent its going down again, keep every other part under—head, legs, arms, all under but your nose; do that, and you cannot sink in any depth of water. All you need do to secure this, is to clasp your hands behind your back, and point your nose upwards towards the heavens, and keep perfectly still. Your nose will never go under water, unless you raise your chin, hand, knee, or foot higher than it.

INSTRUCTIONS FOR SAVING DROWNING PERSONS, BY SWIMMING TO THEIR RELIEF.

1ST.—When you approach a person drowning in the water, assure him with a loud and firm voice, that he is safe.

2nd.—Before jumping in to save him, divest yourself, as far and as quickly as possible, of all clothes; tear them off if necessary, but if there is no time, loose, at all events, the foot of your drawers if they are tied, as if you do not do so, they fill with water and drag you.

3rd.—On swimming to a person in the sea, if he be struggling, do not seize him then, but keep off for a few seconds till he gets quiet, for it is sheer madness to take hold of a man when he is struggling in the water; if you do, you run a great risk.

4th.—Then get close to him and take fast hold of the hair of his head, turn him as quickly as possible on to his back, give him a sudden pull and this will cause him to float, then throw yourself on your back also and swim for the shore, both hands having hold of his hair, you on your back and he also on his, and of course his back to your stomach. In this way you will get sooner and safer ashore than by any other means, and you can easily thus swim with two or three persons; the writer has even, as an experiment, done it with four, and gone with them forty or fifty yards in the sea. One great advantage of this method is that it enables you to keep your head up, and also to hold the person's head up you are trying to save. It is of primary importance that you take fast hold of the hair, and throw both the person and yourself on your backs. After many experiments it is usually found preferable to all other methods. You can, in this manner, float nearly as long as you please, or until a boat or other help can be obtained.

5th.—It is believed there is no such thing as a death-*grasp*, at least it is very unusual to witness it. As soon as a drowning man begins to get feeble and to lose his recollection, he gradually slackens his hold until he quits it altogether. No apprehension need therefore be felt on that head when attempting to rescue a drowning person.

6th.—After a person has sunk to the bottom, if the water be smooth, the exact position where the body lies may be known by the air-bubbles, which will occasionally rise to the surface, allowance being of course made for the motion of the water, if in a tide-way or stream, which will have carried the bubbles out of a perpendicular course in rising to the surface. A body may be often regained from the bottom before too late for recovery, by diving for it in the direction indicated by these bubbles.

7th.—On rescuing a person by diving to the bottom, the hair of the head should be seized by one hand only, and the other used in conjunction with the feet in raising yourself and drowning person to the surface.

8th.—If in the sea, it may sometimes be a great error to try and get to land. If there be a strong "outsetting" tide, and you are swimming either by yourself, or having hold of a person who cannot swim, then get on your back and float till help comes.

9th.—These instructions apply alike to all circumstances, whether the roughest sea or smooth water.

DIRECTIONS FOR RESTORING THE APPARENTLY DEAD.*

Recommended by the Royal Humane Society.

I.—If from Drowning or other Suffocation or Narcotic Poisoning.

SEND immediately for medical assistance, blankets, and dry clothing, but proceed to treat the patient *instantly*, securing as much fresh air as possible.

The points to be aimed at are, *first* and *immediately*, the *restoration* of *breathing*; and secondly, after *breathing is restored*, the *promotion of warmth* and *circulation*.

* The above directions are chiefly Dr. R. Silvester's method of restoring the apparently dead or drowned, and have been approved by the Royal Medical and Chirurgical Society.

The efforts to restore life must be persevered in until the arrival of medical assistance, or until the pulse and breathing have ceased for at least an hour.

Treatment to restore Natural Breathing.

1. **To maintain a Free Entrance of Air into the Windpipe.**—Cleanse the mouth and nostrils; open the mouth; draw forward the patient's tongue, and keep it forward: an elastic band over the tongue and under the chin will answer this purpose. Remove all tight clothing from about the neck and chest.

2. **To adjust the Patient's Position.**—Place the patient on his back on a flat surface, inclined a little from the feet upwards; raise and support the head and shoulders on a small firm cushion or folded article of dress placed under the shoulder-blades.

3. **To imitate the Movements of Breathing.**—Grasp the patient's arms just above the elbows, and draw the arms gently and steadily upwards, till they meet above the head (this is for the purpose of drawing air into the lungs), and keep the arms in that position for two seconds. Then turn down the patient's arms, and press them gently and firmly for two seconds against the sides of the chest (this is with the object of pressing air out of the lungs. Pressure on the breast-bone will aid this).

Repeat these measures alternately, deliberately, and perseveringly, fifteen times in a minute, until a spontaneous effort to respire is perceived, immediately upon which cease to imitate the movements of breathing, and proceed to *induce circulation and warmth.* (*See next page.*)

Should a warm bath be procurable, the body may be placed in it up to the neck, continuing to imitate the movements of breathing. Raise the body in twenty seconds in a sitting position, and dash cold water against the chest and face, and pass ammonia under the nose. The patient should not be kept in the warm bath longer than five or six minutes. But it is preferable that artificial respiration and friction of the limbs and body with dry flannel or cloths should be first had recourse to, and that the warm bath should not be employed till there is proof of respiration having been restored.

4. **To excite Inspiration.**—During the employment of the above method excite the nostrils with snuff or smelling-salts, or tickle the throat with a feather. Rub the chest and face briskly, and dash cold and hot water alternately on them.

Treatment after Natural Breathing has been restored.

5. **To induce Circulation and Warmth.**—Wrap the patient in dry blankets and commence rubbing the limbs upwards, firmly and energetically. The friction must be continued under the blankets or over the dry clothing.

Promote the warmth of the body by the application of hot flannels, bottles or bladders of hot water, heated bricks, etc., to the pit of the stomach, the armpits, between the thighs, and to the soles of the feet. Warm clothing may generally be obtained from bystanders.

II.—If from Intense Cold.

Rub the body with snow, ice, or cold water. Restore warmth by slow degrees. In these accidents it is highly dangerous to apply heat too early.

III.—If from Intoxication.

Lay the individual on his side on a bed with his head raised. The patient should be induced to vomit. Stimulants should be avoided.

IV.—If from Apoplexy or from Sunstroke.

Cold should be applied to the head, which should be kept well raised. Tight clothing should be removed from the neck and chest. Stimulants should be avoided.

Appearances which generally indicate Death.

There is no breathing or heart's action; the eyelids are generally half closed; the pupils dilated; the jaws clenched; the fingers semi-contracted; the tongue appearing between the teeth, and the mouth and nostrils are covered with a frothy mucus. Coldness and pallor of surface increase.

General Observations.

On the restoration of life, a teaspoonful of warm water should be given; and then, if the power of swallowing be returned, small quantities of warm wine or weak brandy-and-water, warm; the patient should be kept in bed and a disposition to sleep encouraged, except in cases of apoplexy, intoxication, and coup-de-soleil. Great care is requisite to maintain the restored vital actions, and at the same time to prevent undue excitement.

The treatment recommended by the Society is to be persevered in for three or four hours. It is an erroneous opinion that persons are irrecoverable

because life does not soon make its appearance, as cases have come under the notice of the Society of a successful result even after five hours' perseverance —and it is absurd to suppose that a body must not be meddled with or removed without the permission of a coroner.

RESTORING THE APPARENTLY DROWNED.

THE following directions for restoring the apparently drowned are issued by the United States Life Saving Service; they are those of Dr. Howard:—

Where you can do so, send immediately for a regular medical practitioner.

1. **Arouse the Patient.**—Unless in danger of freezing, do not move the patient, but instantly expose the face to a current of fresh air, wipe dry the mouth and nostrils, rip the clothing, so as to expose the chest and waist, and give two or three quick smarting slaps on the stomach and chest with the open hand. If the patient does not revive, proceed thus:—

2. **To draw off Water, etc., from the Stomach and Chest.**—If the jaws are clenched, separate them, and keep the mouth open by placing between the teeth a cork, or small bit of wood; turn the patient on the face, a large bundle of tightly rolled clothing being placed beneath the stomach, and press heavily over it for half a minute, or so long as fluids flow freely from the mouth.

3. **To produce Breathing.**—Clear the mouth and throat of mucus by introducing into the throat the corner of a handkerchief wrapped closely around the forefinger; turn the patient on the back, the roll of clothing being so placed as to raise the pit of the stomach above the level of any other portion of the body. If there be another person present, let him, with a piece of dry cloth, hold the tip of the tongue out of one corner of the mouth (this prevents the tongue from pulling back and obstructing the windpipe), and with the other hand grasp both wrists, and keep the arms forcibly stretched back above the head, thereby increasing the prominence of the ribs, which tends to enlarge the chest. The two last-named positions are not, however, essential to success. Kneel beside or astride the patient's hips, and with the balls of the thumbs resting on either side of the pit of the stomach, let the fingers fall into the grooves between the short ribs, so as to afford the best grasp of the waist. Now, using your knees as a pivot, throw all your weight forward on your hands, and at the same time squeeze the waist between them, as if you wished to force everything in the chest upward out of the mouth:

deepen the pressure while you can count slowly one, two, three; then suddenly let go with a final push, which springs you back on your first kneeling position. Remain erect on your knees while you can count one, two, three; then repeat the same motions as before, at a rate gradually increased from four or five to fifteen times in a minute, and continue thus this bellows movement, with the same regularity that is observable in the natural motions of breathing which you are imitating.

If natural breathing be not restored after a trial of the bellows movement for three or four minutes, then, without interrupting the artificial respiration, turn the patient a second time on the stomach, as directed in Rule 2, rolling the body in the opposite direction from that in which it was first turned, for the purpose of freeing the air passages from any remaining water. Continue the artificial respiration from one to four hours, or until the patient breathes; and for a while after the appearance of returning life, carefully aid the first short gasps until deepened into full breaths. Continue the drying and rubbing, which should have been unceasingly practised from the beginning, taking care not to interfere with the means employed to produce breathing. Thus, the limbs of the patient should be rubbed, always in an upward direction towards the body, with firm grasping pressure and energy, using the bare hands, dry flannels or handkerchiefs, and continuing the friction under the blankets, or over the dry clothing. The warmth of the body can also be promoted by the application of hot flannels to the stomach and armpits, bottles or bladders of hot water, heated bricks, stones, etc., to the limbs and soles of the feet.

4. **After-Treatment.**—*Externally:* As soon as breathing is established, let the patient be stripped of all wet clothing, wrapped in blankets only, put to bed comfortably warm, but with a free circulation of fresh air, and left to perfect rest.

Internally.—Give a little brandy and hot water, or other stimulant at hand, every ten or fifteen minutes during the first hour, and as often thereafter as may seem expedient.

Later manifestations.—After reaction is fully established there is great danger of congestion of the lungs, and if perfect rest is not maintained for at least forty-eight hours, it sometimes occurs that the patient is seized with great difficulty of breathing, and death is liable to follow unless immediate relief is afforded. In such cases apply a large mustard plaster over the breast. If the patient gasps for breath before the mustard takes effect, assist the breathing by carefully repeating the artificial respiration.

ACCIDENTS.

Rules for the Course to be followed by the Bystanders in case of Accidents, where Surgical Assistance cannot be at once obtained.

The following rules describing aids for cases of injuries or sudden illness, are principally extracted, by the kind permission of the St. John Ambulance Association, from the Handbook compiled for the use of the St. John Ambulance Association classes, by the late P. Shepherd, M.B.

Important Diseases and Injuries of the Head.

The following conditions are of such frequent occurrence that their symptoms and treatment should be clearly understood and remembered.

Intoxication.

Cause.—Excess in drink.

Symptoms.—Odour of liquor in breath, insensibility usually not complete, patient can usually be roused. no stertorous breathing, pupils of equal size, and usually dilated (large), cornea sensitive to touch, temperature of body 2° to 3° below normal, pulse soft and frequent, no difference between sides of body, both being equally helpless.

Treatment.—Emetics; cold water applied to head; warmth to surface of body and extremities.

Apoplexy.

Cause.—Effusion of blood producing pressure on the brain.

Symptoms.—Patient becomes suddenly insensible, face flushed or very pale, pulse full, breathing stertorous, convulsions, paralysis.

Treatment.—Place body in lying-down position, with the head raised; undo clothing around neck, apply iced or cold water to head, not to give the patient anything by mouth.

Epilepsy.

Cause.—Disease or disorder of brain.

Symptoms.—Convulsions, foaming at mouth, biting tongue, partial insensibility, breathing laboured, pulse normal, face livid.

Treatment.—Prevent patient injuring himself, raise the head.

Hysteria or Hysterical Epilepsy.

Associated with other forms of Hysteria.

Symptoms.—Falls suddenly but carefully, convulsions, *or rather* jerking of the head and body, partial insensibility, apparent but not real.

Treatment.—Cold douche to face.

Syncope or Fainting.

Causes.—Debility or mental shock.

Symptoms.—Insensibility, face and lips pallid, pulse almost imperceptible, cold sweat over skin.

Treatment.—Cold douche to head and face, a little weak stimulant; place your hand behind the patient's head, and press it down between the knees.

Blood Poisoning.

Cause.—Kidney disease.

Symptoms.—Convulsions, insensibility, twitching of muscles, delirium, breath has a urinous odour, signs of dropsy.

Treatment.—Hot air or vapour bath, active purgatives, ice to head.

Opium or Morphia Poisoning.

Symptoms.—Stupor, pupils contracted to a pin's point, progressive insensibility, which is seldom complete till convulsions or death occurs.

Treatment.—Emetics, cold douche to head and chest, walking exercise, strong coffee, artificial respiration, shock from galvanic battery.

Shock or Collapse.

Cause.—Injuries to nervous system by blows, operations, fright, grief, lightning; death may be instantaneous, recovery may be slow or rapid.

Symptoms.—Face pale and pinched, eyes dull, pulse almost imperceptible, breathing very feeble, the functions of respiration and circulation are reduced to a minimum.

Treatment.—Place patient in horizontal position, restore circulation and respiration, remove tight-fitting clothing from neck, apply warmth to surface of body and extremities; stimulants may be given cautiously in small quantities.

Concussion of Brain.

Causes.—Blows or falls on head.

Symptoms.—External bruises, etc. In *slight cases*, patient lies motionless and insensible. If roused, answers hastily and then relapses. After a time becomes restless, and vomits, and recovers. In *severe cases*, patient is profoundly insensible; surface pale and cold; pulse feeble; breathing slow and sighing.

Treatment.—Place patient on his back, with head slightly raised, in a dark, quiet room; apply warmth to surface of body and extremities.

Compression of Brain.

Causes.—Pieces of bone or hæmorrhage pressing on substance of the brain.

Symptoms.—Those of apoplexy, following some injury to head, such as fracture of the skull.

Treatment.—The same as in apoplexy.

Hæmorrhage.

Hæmorrhage, or bleeding, is the result of the opening of a blood-vessel by a wound or otherwise. It may be external or internal.

Hæmorrhage is divided into—(1) *Arterial*, where the blood flows in jets in great force, and is of a bright red colour. (2) *Venous*, where it flows slowly—wells out—and is of a dark, purple hue. (3) *Capillary*, where there is a general oozing of red blood from the surface.

General Treatment of Hæmorrhage.—Pressure is the most powerful means of arresting external hæmorrhage; and to use it effectively, it is important that the pressure should be directed against some bone as a point of resistance.

In all portions of the body where special treatment is not specified, direct pressure to the wounded part will be sufficient to arrest hæmorrhage till further assistance can be procured.

Arterial Hæmorrhage is the most important and the most dangerous form of bleeding, and not a moment ought to be lost in giving help.

Treatment.—1. Expose and examine wound.

2. Wash with cold water.

3. Elevate the bleeding part, but place body in the lying-down position.

4. Apply pressure with the fingers directly over the mouths of the bleeding vessels till you can get further help.

5. Apply pressure to the main artery on the heart side, with the fingers or with a pad and bandage (tourniquet).

6. Apply a pad and bandage over wound as an additional safeguard.

Venous Hæmorrhage may occur along with arterial, or by itself. A superficial wound is more likely to divide veins than arteries. Dangerous venous bleeding often takes place where the patient has varicose veins and ulcers on the lower limbs.

(The direction of the flow of blood—towards the heart—just the reverse of what obtains in the arteries, is a fact which bears on the treatment.)

Treatment.—1. Expose and examine wound.

2. Wash well in cold water.

3. Elevate limb, keeping body in lying-down position.

4. Apply a pad and bandage on both sides of wound.

5. Remove any pressure or restriction to the circulation on the heart side, such as tight clothing (this cannot be done where arterial bleeding has also to be treated).

Capillary Hæmorrhage is easily controlled.

Treatment.—1. Direct pressure to the bleeding surface.

2. Application of ice or of styptics, such as alum, steel drops, caustics, etc.

Internal Hæmorrhage is seldom so rapid, except in cases of bursting of an aneurism, as not to give time for skilled aid.

Treatment.—1. Place patient in an easy recumbent position.

2. Apply ice to, or as near as possible to, the part affected.

3. Sucking ice is useful in bleeding about mouth, throat, or air-passages.

FRACTURES.

Symptoms of Fracture.

The symptoms of fracture are—

1. The inability to use the limb.

2. Alteration in shape and general appearance.

3. Unusual mobility at seat of fracture.

4. Crepitus or crackling on placing one hand over the broken part, and creating motion with the other.

5. Shortening of limb.

6. Some inequality felt on running the fingers along the surface of the injured bone.

Fractures are distinguished from dislocations as follows:—

Fractures.—Crepitus, unnaturally movable, easily replaced, limb often shortened, seat of injury in the shaft or body of the bone.

Dislocations.—No crepitus, more or less fixed, replaced with difficulty, limb may be shortened or lengthened, seat of injury at a joint.

Treatment of Fractures.

1. Reduce the fractured ends or portions to their natural position.

2. Retain them immovably in their proper places till nature has effected a permanent cure.

There is no urgency about treating a broken limb provided no attempt is made to move the person, but if it is imperative that the patient be moved in the absence of a surgeon, it is an absolute necessity to secure the safety of the limb by putting it in splints before removal.

A stretcher is the only safe means of conveyance for cases of fracture.

Unskilful handling may cause either serious mischief or even loss of life; the dangers are pressing the sharp ends through the skin, and thus making the fracture compound, or through blood-vessels, nerves, or into some internal organ, such as the lungs.

SPECIAL FRACTURES.

Fracture of the Skull.

Causes.—Blows or falls.

Symptoms.—External signs not always present. In fracture of the base there may be hæmorrhage from ear, mouth, or nose; red patches of blood under conjunctivæ of eyes; and oozing of watery fluid from the ears.

Accompanying these there may be symptoms of concussion, or symptoms of compression.

Treatment.—Place patient in a dark and quiet room on his back, with head slightly raised. Apply cold to head as soon as reaction sets in and patient gets hot and feverish.

Fracture of Lower Jaw.

Causes.—Direct blows; fall on chin.

Symptoms.—Irregularity in the line of the teeth and the outline of the lower margin of bone; inability to move jaw.

Treatment.—Fix lower jaw to upper jaw by a bandage.

Fracture of Collar Bone.

Causes.—Blows on shoulder; falls on elbow or hand.

Symptoms.—Shoulder drops, arm is helpless, irregularity on drawing finger along surface of bone, patient inclines head to the injured side, and supports the elbow with the sound hand.

Treatment.—Place a pad in armpit, bind arm to side just above elbow, and sling forearm.

Fracture of Ribs.

Causes.—Blows, falls, weight passing over chest or back.

Symptoms.—Catching pain and difficulty in breathing, which is jerky and shallow, and crepitus when patient coughs.

Treatment.—Apply a broad roller bandage firmly round chest, so as to prevent all movement; or strap the injured side with adhesive plaster.

Fracture of the Humerus.

Causes.—Direct blows; falls on elbow.

Symptoms.—Mobility at seat of fracture, crepitus, shortening, usually present when fracture is oblique.

Treatment.—Apply a roller bandage from hand to elbow, abduct arm and apply three or four splints from shoulder to elbow. Support arm in a sling.

Fracture of the Forearm.

Causes.—Direct violent blows, falls.

Symptoms.—Crepitus, mobility, alteration in shape of arm.

Treatment.—Semiflex forearm with thumb pointing upwards. Apply two splints, one inside from bend of elbow to the tips of the fingers, and one outside from elbow to wrist. The splints should be well padded. Place arm in sling.

Fractures about Wrist and Hand.

Causes.—Blows or other injuries.

Symptoms.—Pain, swelling, irregularity in the outline of the bones, crepitus.

Treatment.—Bandage to a flat board or splint, and support by sling.

Fracture of Femur or Thigh Bone.

Causes.—Blows, falls.

Symptoms.—Pain and loss of power, crepitus, shortening, broken ends may be felt, foot turned out.

Treatment.—Extend the limb, apply a long splint on outside along the whole side, from the armpit to the outside of the heel, another on the inside of the thigh, from top of the inside of the thigh to the knee.

Fracture of Patella or Knee-cap.

Causes.—Blows, or excessive muscular action.

Symptoms.—Inability to stand upon leg. Fragments can be felt.

Treatment.—Raise limb on a splint to a position oblique with the body, and apply a figure-of-eight bandage around the knee, including the fragments.

Fracture of Bones of the Leg.

Causes.—Blows, falls, crushing weight, such as wheels passing over the limb.

Symptoms.—Pain and loss of power, alteration in shape, crepitus, broken ends may be felt.

Treatment.—Apply two splints, one inside and one outside the limb. Elevate limb.

Fractures about Foot and Ankle.

Causes.—Blows or other injuries.

Symptoms.—Pain, swelling, alteration in outline of bones, crepitus.

Treatment.—Elevate foot; apply cold water. Before applying any splint, be careful to pad it well with some soft material, as tow, wadding, cotton wool, etc.

N.B.—It must be remembered, that the treatment for fractures here given is only temporary, to enable the patient to be moved without further injuries, which might result in the loss of the limb or even life, till a surgeon can be sent for.

The treatment for dislocations is purposely omitted, as being dangerous, except in the hands of a surgeon.

To place a Man on a Stretcher with Three Bearers.

1. The three men fall in facing the feet of the injured man, and are numbered off from the right.

2. Put the foot of the stretcher at the man's head, in a line continuous with his body.

3. Nos. 1 and 2, one at either side, locking hands underneath the shoulders and hips, raise the patient; carry him forward over the stretcher; and then lower him on to it.

4. No. 3 takes charge of the injured portion (*limb* or *head*), and steadies it with a hand on either side of the wound.

5. Nos. 1 and 2 then take their places at head and foot of stretcher, lift and carry off, while No. 3 walks at the side of the stretcher as a safeguard to the patient, and as a relief to No. 1 or 2 if necessary.

Rules for Carrying a Stretcher.

1. Carry stretcher in hands, or suspend it by straps over the bearers' shoulders.
2. Never allow the stretcher to be placed on the shoulders.
3. Bearers to march in broken step, and not in time.
4. Avoid all jolting, crossing fences, ditches, etc.
5. Pace to be about 20 inches.
6. In ascending, patient's head to be in front, and in descending behind.

Splints.

Splints are appliances used in treating fractures, for supporting the bones in their natural position till a cure is effected.

The materials chiefly used for making splints are wood, iron, pasteboard, leather, gutta-percha, felt, wire, tin, and bark. Extemporized splints may be formed with umbrellas, walking-sticks, cigar-boxes, folded newspapers, policemen's truncheons, and soldiers' weapons, such as rifles, swords, or bayonets.

Pads.

Splints should be well padded with wool, cotton wool, tow, flannel, or lint.

Sprain.

A *sprain* or strain is a twist or over-extension of a muscle or tendon or ligament about a joint, usually with rupture of some of its fibres and of small blood-vessels. In rheumatic people it is often followed by persistent pain.

Treatment.—If there be great pain, a hot bath and fomentations with complete rest; later on, embrocations, friction, cold and warm douches, and passive movements are requisite, according to the severity of the accident.

WOUNDS.

Incised Wounds.

Treatment.—Wash the part carefully with water, arrest the hæmorrhage, adjust the edges and fix in a natural position, place patient in an easy position, so as to avoid straining the parts, apply cold-water dressing, or strips of adhesive plaster.

In wounds of throat, sand-bags are good supports for fixing head and neck.

Incised Wounds, with Protrusion of Internal Organs.

Treatment.—Wash the parts carefully with warm water, and return, unless they are much injured, and place patient in a thorough state of rest.

In incised wounds about the face it is very important to replace the wounded portions with as little delay as possible.

Contused and Lacerated Wounds.

These wounds are more dangerous and troublesome to heal, besides being liable to erysipelas, gangrene, etc.

Treatment.—Wash, arrest hæmorrhage, replace parts in their natural position, apply cold-water dressings, and never allow them to get dry.

Foreign Bodies in the Eye.

If the foreign body is under the upper eyelid, seat the patient in a chair, and standing behind, place a pencil over the lid; lay hold of the eyelashes, and evert the lid. Then, having exposed the substance, brush it off with the corner of a handkerchief or a camel's hair brush. If it is under the lower eyelid, simply depress it, and proceed as above with handkerchief or brush.

Foreign Bodies in the Ear.

The canal leading to the inside of the ear is about an inch and a quarter in length, and at the inner end of this canal is placed the drum of the ear—a very thin, delicate membrane, resembling a piece of tissue paper.

A blow on the ear with the open hand, or the concussion from the discharge of firearms, is quite sufficient to rupture and destroy this membrane. No interference, therefore, with the ear, beyond using a syringe, should be attempted, except by a surgeon. Such substances as accumulations of wax, pieces of slate-pencil, insects, etc., may be removed by syringing with tepid water. It will be well, however, to remember that peas and porous substances, which absorb moisture, would be rendered more difficult of removal after the use of the syringe.

Burns and Scalds.

A *burn* is caused by concentrated heat, fire directly applied to surface, or chemical agents, destroying the skin and the tissues underneath.

A *scald* is produced by hot or boiling liquids touching the skin; the cuticle is raised and the true skin reddened and inflamed.

Besides their local action, burns and scalds are apt to produce dangerous effects by congestion of internal organs.

Treatment of Burns.—Apply a mixture of oil and lime-water, olive oil, castor oil; and wrap up the part in cotton wool, wool, or flannel.

Treatment of Scalds.—Apply a strongly alkaline solution made with the carbonate of soda, lime, or magnesia; and enclose the limb, or part, in cotton wool, excluding air as far as possible.

N.B.—Troublesome contracting scars, causing deformity, often follow burns; it is therefore important to make the patient lie in a natural position, and avoid twisting the neck or doubling up the limbs.

Frost-Bite.

Frost-bite is the result of exposure to severe cold. The vitality of the part is reduced to a very low point, the part loses its natural colour, and becomes blue or purple.

Treatment.—Bring about reaction gradually by friction. Place the patient in a room without a fire, and avoid heat. Rub the part with snow or other cold application, and administer brandy-and-water carefully in small quantities.

Bites of Rabid Animals.

Treatment.—If possible, immediately apply a ligature on the side nearest the heart; bathe the wound with warm water, so as to encourage bleeding; scarify around it to the depth of a quarter of an inch: use caustics, such as nitrate of silver or carbolic acid. The internal use of brandy and ammonia is necessary.

Rules for Treatment of Cholera.

Cholera is almost invariably preceded by a painless diarrhœa, and this should, in all cases, be promptly treated.

When diarrhœa is present, go to bed and maintain the horizontal position; use abundance of blankets. Stay in bed until you are well; do not consider

yourself well until you have had a natural movement of the bowels. Let no solid food be used, everything to be fluid, as milk, soup, a soft-boiled thin egg or arrowroot. Apply mustard plasters to the abdomen. In the absence of a physician, an adult can take ten drops of laudanum, and ten drops of spirits of camphor. A child of ten may take five drops of each. A child of five years may take three drops of each. Never chill the surface of the body by getting out of bed.

*** Opium is dangerous to old people, as well as very young; and should not be repeatedly administered, without medical supervision.

Fever and Ague.

Fever and ague is always preceded by an ague fit: it has three stages, the cold, hot, and sweating stage.

1st.—The cold, when teeth chatter.

2nd.—The hot, with high fever.

3rd.—The sweating, when moisture appears, and feeling of health returns.

In the event of there being no physician: in cold stage give *hot* drinks, hot foot-bath, hot bottles to sides and limbs.

In hot stage, give cooling drinks, half teaspoonful of sweet spirits of nitre in water every two hours.

During sweating stage, rub with dry towels. In *intermission* give quinine in from two to ten grain doses every three hours, for a few doses; afterwards give ten drops of tincture of iron three times a day for a week. Avoid the hot sun, and damp evening and morning air. If singing in the ears should come on while taking quinine, the dose should be either lessened or suspended altogether.

Marsh Poison.

When men are employed on detached service in boats, or are otherwise exposed in a swampy region, they should be supplied with quinine to guard them against the marsh poison. Four grains should be administered before starting in the morning, and four on their return; but if they should be exposed for twelve hours, or if the exposure be overnight, the quinine should be continued until they return on board, and for fourteen days afterwards. The quinine might affect the head, by producing buzzing and noise in the ears. When this happens, the dose should be reduced in quantity, or perhaps discontinued.

Strength for one dose:—

Quinine	4 grains.
Dilute sulphuric acid	10 drops.
Water	2 ounces
Rum	1 ounce.

By simple multiplication, the above may be mixed, at once, for any number of men daily.

Poisonous Fish.

At certain seasons, some fish, when eaten, produce poisonous effects. If vomiting has already occurred, it should be encouraged, by giving lukewarm water to drink, or it may be rendered more decided by the administration of the mustard emetic; after the stomach has been well cleared out and has had a little rest, a table-spoonful of castor oil or half a drachm of rhubarb may be given with advantage.

Sunstroke.

Take the patient immediately into the shade, place in a semi-recumbent position; head raised, loosen the clothes about neck and chest; apply immediately ice or cold wet cloths to the head and nape of the neck, changing them frequently; then douche over head, spine, and chest, from a height of about three feet. Patient to be fanned to produce a cool current of air. Mustard to limbs and sides—stimulants.

POISONS.

POISONS are substances capable of destroying life. They are divided into classes, according to their action on the body.

1. *Irritants* destroy the tissues, and produce nervous shock.
2. *Narcotics* produce insensibility by their action on the brain.
3. *Narcotico-irritants* combine the action of narcotics and irritants.

Symptoms.—Are the sudden attack of vomiting, purging, cramps, pain in the stomach, delirium, or unconsciousness soon after partaking of food or drink.

Treatment.—The points to be kept in view in poisoning are:—

1. To get rid of the poison by encouraging vomiting.

2. To counteract the effects of the poisons by antidotes, which will mechanically or chemically render the poison harmless.

3. To remedy the effects produced, and obviate the tendency to death by stimulants, artificial respiration, and exciting the excretory organs.

Emetics.

Emetics are remedies used for the purpose of causing vomiting. The safest and readiest are—irritating back of throat with the finger or a feather; large draughts of tepid water combined with a table-spoonful of salt or mustard; one or two table-spoonfuls of ipecacuanha wine in water; and twenty grains of sulphate of zinc in water.

Acids and Alkalies form antidotes to each other. The acids suitable for the purpose are vinegar, lime juice, and orange juice, mixed with water.

The alkalies are soda, potash, lime, and magnesia diluted with water.

Albumen and Oils will protect the gullet and walls of the stomach in poisoning by irritants. White of egg, milk, flour-and-water, salad oil, and castor oil may be used.

The Stomach Pump cannot be used except by a surgeon, but a very good substitute can be found in a piece of gutta-percha tubing, provided the patient is not in an insensible condition. Take three yards of elastic gutta percha tubing, about half-an-inch in diameter, make the patient swallow about twenty to twenty-five inches of it; raise the free end above his head and pour down a pint of water, or as much as the stomach will receive. Then lower the free end, and it will empty itself; repeat the filling and emptying as often as you think necessary. This remedy is perfectly safe and effectual; it has been used by German physicians for disorders of the stomach with considerable success. The swallowing of the tube can be done with the greatest facility, without assistance and without danger.

Poisons.	Antidotes.
Arsenic	Emetics; milk; peroxide of iron; eggs; castor oil; salad oil.
Antimony (*Butter of Antimony and Tartar emetic*).	Encourage vomiting. Milk; tea; nic acid.
Mineral Acids (*Oil of Vitriol, Aquafortis, Spirit of Salt*).	Encourage vomiting. Alkalies– tions of soda; potash; lime; nesia; whiting; wall plaster.

Poisons.	Antidotes.
Oxalic Acid, Carbolic Acid .	Olive oil.
Alkalies (*Caustic Potash, Soda, or Lime*)	Acids — vinegar and water; lime juice; orange juice in water; emetics; salad oils.
Phosphorus—(*Rat Poison*) . .	Encourage vomiting by large draughts of water. Large doses of magnesia in water. Avoid oils.
Mercury Salts (*Corrosive Sublimate, Calomel*)	Encourage vomiting; white of eggs; flour and water; milk.
Salts of Lead (*Sugar of Lead, Paint*)	Emetics and Epsom salts.
Nitrate of Silver—Caustic .	Common salt and water.
Irritant Gases (*Chloroform*) .	Fresh air; loosen dress; artificial respiration; dash cold water about face and neck.
Prussic Acid	Cold douche; smelling salts to nostrils; artificial respiration; brandy and ammonia.
Strychnia	Emetics; cold affusion; artifical respiration; brandy and ammonia.
Narcotics (*Opium, Morphia*). (*See* page 342)	Emetics; strong coffee; cold affusion; forced walking about; galvanism.
Alcohol (*See* page 341) . . .	Emetics; cold affusion; warmth to surface of body; a dessert-spoonful of vinegar in water.

Modes of Death.

Death may occur in three different ways, according as it begins in the heart, lungs, or head.

1. Heart—by *syncope*, as in *hæmorrhage*.
2. Lungs and air-passages—by *asphyxia*, as in *drowning*.
3. Head—by *coma*, as in *apoplexy*.

Signs of Death.

The most obvious signs of death are—Cessation of breathing, no movement of chest, no moist breath to dim a looking-glass placed before mouth.

Cessation of heart's action, no impulse against side or pulse beating in arteries. Eyelids half closed, eyes dim and glassy, pupils dilated, jaws clenched, tongue appearing between teeth, frothy mucus about nose and mouth, fingers half-closed, and after a time, body rigid and surface cold.

Causes of Sudden Death.

The chief causes of sudden death are—Apoplexy, aneurism, heart disease, suffocation, injuries to the nervous system, sunstroke, lightning, poisoning.

COOKERY.*

Boiling meat entails a loss in weight of about 30 per cent. The water should never be higher than 160° Fahr.; if hotter the meat becomes hard and shrunken; the lower the temperature the better are the nutritive juices kept in. The larger the pieces of meat the better. Put the meat into boiling water, let it boil for five minutes, and then reduce the temperature of the water, either by pouring in cold water, or by reducing the fire until it is about 160° Fahr., that is, as hot as the finger can be put into without scalding. Allow a quarter of an hour for every pound the meat weighs.

Roasting.—The loss is a little less than in boiling. The meat should be exposed at first to a great heat for the purpose of keeping in the juice. Allow a quarter of an hour a pound.

Meat Soup.—16½ lbs. meat, 1 lb. onions, 1 lb. flour, 5 ozs. salt, ½ oz. pepper, 5 ozs. sugar, small faggot of herbs, and 3½ galls. water. Separate the *large* bone from the meat, also the gristle, cut the meat into pieces of about 4 ozs., take 8 ozs. of the fat and chop it up, slice the onions, put the fat in the boiler; when melted, add the onions, stir them well, so that they do not get brown, in five minutes add the meat, which keep stirring and turning over for five minutes longer; the meat ought to be warm through. Then add the boiling water by degrees, let it simmer gently for an hour, mix the flour with cold water very smooth, add it to the soup with the salt, pepper, sugar, and herbs; simmer gently for thirty minutes, keep stirring it to prevent the flour from settling at the bottom. The great error commonly committed in making soup, is doing it too rapidly, which renders the meat hard and

* From *The Soldier's Pocket Book.*

tasteless. Bones and scraps of meat should be collected after every meal and put down to simmer for next day's soup.

Irish Stew.—16½ lbs. meat, 16 lbs. potatoes, 4 lbs. onions, 6 ozs. salt, 1 oz. pepper, ¼ lb. flour. Cut the meat away from the bone, and then into pieces of a ¼ lb. each, the loin and neck of mutton into chops, disjoint the shoulder, and cut the blade bone into four pieces; if the leg, cut into slices, ¾ inch thick, rub them with salt, pepper, and flour, and place the meat in the boiler with some fat, brown it on both sides, then add the onions whole, and then the potatoes; stew gently for two hours; keep the fire down and well covered during the cooking.

How to Soak and Plain Boil the Rations of Salt Meat.—To each pound of meat allow ½ pint of water, or a pint if handy; do not let the pieces weigh more than 3 lbs. or 4 lbs. each. Let them soak about eight hours, or all night if possible. Wash each piece with the hand to extract as much salt as possible; it is then ready for cooking. If less time is allowed, cut the pieces smaller, or parboil the meat for twenty minutes in the above quantity of water, which throw off, and add more; simmer gently for three hours and serve. Vegetables or dumplings can be boiled with it.

Salt Meat, to prepare hurriedly.—Warm it slightly on both sides—this makes the salt draw to the outside—then rinse it well in a pannikin of water. This process is found to extract a great deal of salt, and to leave the meat in a fit state for cooking. For a hurried dinner cut your rations into pieces about the size of a penny, but three or four times thicker; skewer them on a piece of iron wire or hard stick. A few minutes will cook them if hung before the fire.

How to Stew Fresh Beef, Pork, Mutton, and Veal.—Cut or chop 2 lbs. of fresh beef into ten or twelve pieces, put these into a saucepan with 1½ teaspoonful of salt, 1½ teaspoonful of sugar, ½ teaspoonful of pepper, 2 middle-sized onions sliced, ½ pint of water. Set on the fire for ten minutes until forming a thick gravy. Add a table-spoonful of flour, stir on the fire a few minutes; add a quart and a half of water; let the whole simmer until the meat is tender. Beef will take from two hours and a half to three hours; mutton and pork about two hours; veal one hour and a quarter to one hour and a half. If onions, sugar, and pepper are not to be had, meat thus prepared will even then make a good dish; with ½ lb. of sliced potatoes or 2 ozs. of preserved potatoes; ration vegetables may be added, also a small dumpling.

Vegetables must be carefully washed and cleaned from insects. Green vegetables must be boiled fast in plenty of water, and drained at once when done. They sink when sufficiently cooked. *Potatoes* take from twenty to

thirty minutes boiling; they show signs of breaking when they are done, which can be ascertained by sticking a fork into them. *Carrots* and *Parsnips* take from twenty to forty-five minutes boiling. *Young nettles, sweet docks, turnip tops,* or the young leaves of *mangel wurtzel,* make good green food; a little pepper and salt should be added to season them. *Dandelion leaves,* especially when young, make a most agreeable salad.

Dried and Compressed Vegetables of all kinds should be soaked from four to six hours in pure water, and then boiled slowly; if there is any bad taste, from putrefication having commenced, a little chloride of lime will remove it. The "*mixed compressed vegetables*" should be boiled in a little water for about half an hour; the *cabbage* to be boiled in sufficient water for half an hour; the *carrots* and *turnips* to be boiled for about fifteen minutes; *potatoes* to be boiled in sufficient water for half an hour. *Rice* should be washed and soaked, and then boiled in plenty of water, *without salt,* for twenty or twenty-five minutes; then some salt should be thrown in, and the water drained off. Each grain will then be separate.

To make Tea.—If possible it should be made in a vessel solely used for that purpose; on service this is generally impossible, but it renders great care on the part of the cook all the more essential. Before the tea is made the kettle must be well washed, and heated with a little hot water and well rinsed. The water for the tea should then be put in, and boiled before the tea is put in. Care to be taken that the water is boiling fast when this is done. If possible the boiling water should be poured from one kettle into another containing the dry tea. The lid should then be put on, and the pot placed beside (but not on) the fire for four or five minutes before serving it out. Much depends on the softness of the water; if the water is hard, add, when possible, half a teaspoonful of carbonate of soda to the camp kettle full (for five men each).

To make Coffee.—The same rules apply, as regards cleanliness and the description of water, as in making tea. Sometimes there is only time to prepare it for boiling; but, if possible, it is better to heat the coffee in the lid of the kettle; then put it in a kettle, and pour the boiling water on it, leaving it to stand near the fire for five minutes, when it will be fit for use. When there is time to do so, it should be strained through a cloth of some sort; when made, the dregs should be collected and well boiled. If this decoction is poured over fresh coffee the result of the second making will be found strong and aromatic. To clear coffee some cold water should be poured in from a height. The cold water sinks through the coffee, and carries down the suspended particles.

COOKERY FOR THE SICK.

Arrowroot.—Take a small table-spoonful of arrowroot, mix or blend it smoothly in two table-spoonfuls of cold water. Then add half a pint of boiling water, and stir it until it thickens; add sugar. A little wine will render it more agreeable.

Water Gruel.—Rub a table-spoonful of oaten meal smooth in a little cold water, add this to a pint of boiling water (on the fire), stir gently for a quarter of an hour. Let it settle; pour off from dregs, and add a little salt and butter.

Barley Water.—Wash a handful of barley, and simmer in three pints of water. A little lemon peel will flavour it.

Beef Tea.—Take one pound of rump steak, mince it fine, and mix it with one pint of cold water; place by the fire to heat *very* slowly. It may stand two or three hours before it is allowed to simmer, then boil for fifteen minutes, skim and serve. Good in fever and debility.

Egg Flip.—Beat up the raw yolk of two eggs, add half a pint of milk. Nourishing and useful in fever.

Lemonade.—Half a lemon squeezed into a pint of warm water; sweeten and allow to cool. Or, one ounce of lime juice instead of the lemon.

WATER.

In all localities where the quality of the water is suspicious, condensed water should, if possible, be used for drinking and cooking purposes. When this is not feasible, the water should be carefully filtered and boiled.

Two barrels, one inside the other, having a space of four to six inches clear all round between them, filled with layers of sand, gravel, and charcoal, form an excellent filter. The inside one, without a bottom, rests on three stones placed in layers of sand, charcoal, and coarse gravel; the water, flowing or being poured into the space between the two barrels, and having thus to force its way through the substances into the inner barrel, becomes purified.

The water should be drawn off by means of a pipe, running through the outer into the inner barrel. Animal charcoal is the best. When, after a time, it ceases to act, it should be removed and well dried. It can then be used again with advantage. It is impossible to use too much of it.

The popular French plan of purifying turbid water (*alunage de l'eau*) simply consists in the addition of a small quantity of alum. It clears the water very rapidly, but merely converts the lime carbonate into sulphate which remains in solution.

DISINFECTION.

The terms *infectious* and *contagious* (*catching*) applied to a disease signify that it is communicable from the sick to the healthy.

The following are the principal infectious diseases:—

Eruptive fevers—measles, small-pox, and scarlet fever.

Continued fevers—typhus, typhoid, relapsing, and yellow fevers; diphtheria, erysipelas, whooping-cough, and cholera.

Disinfectants are materials used for the purpose of purifying the air, water, soil, etc., by removing or rendering inert certain noxious substances.

The most common patent disinfectants are:—

Condy's fluid, Burnett's fluid, Ledoyen's fluid, Dougall's powders, Sirel's compounds.

Rules for Disinfecting an Unoccupied Room.

1. Close every door and window, and stop up every opening or crevice with old rags or tow.

2. Fumigate by any of the following methods:—

(1) **By Chlorine.**—Place a few saucers in different parts of the room, containing a mixture of one part of common salt, one part of black oxide of manganese, and two parts of oil of vitriol.

(2) **By Iodine.**—Place two drachms of iodine in a metal cup or vessel, and place a lamp or burning candle underneath it till it evaporates.

(3) **By Sulphurous Acid.**—Burn sulphur in saucers.

(4) **By Nitrous Acid Fumes.**—Place several cups into saucers or basins containing hot water, and inside the cups put two ounces of nitrate of potash and one ounce of sulphuric acid.

(5) **By Carbolic Acid.**—Place some pure carbolic acid in shallow vessels around the room.

3. Furniture and floors to be well washed or scrubbed with a solution of chloride of lime; the latter may be sprinkled with the powdered chloride of lime or Dougall's powder.

4. Papers to be stripped from the walls, and the walls and ceilings to be white-washed.

5. All clothing to be disinfected by washing, boiling, baking in an oven, or exposure to the sun or before a fire, if a disinfecting establishment is not available.

6. Curtains and carpets are best disinfected by exposure to a heat of from 200° to 400° Fahr.

7. In extreme cases, destroy by fire all clothing, bedding, carpets, etc.

Rules for Disinfecting an Occupied Room.

1. Maintain a proper state of ventilation by doors, windows, and outer openings.

2. Keep up a good fire in the room.

3. Use Condy's fluid, Burnett's fluid, or solutions of chloride of lime for utensils in room, closets, etc.

4. Disinfect all clothing, linen, etc., before it leaves the room, as laid down in following rule 8, for preventing spread of diseases.

5. Fumigate room cautiously with either chlorinated lime or carbolic acid, placed in saucers in different parts of the room.

Be careful not to use gases or vapours too freely, as they are liable to cause inconvenience to the patient, by irritation of the lungs or air-passages.

Rules for the Prevention of the Spread of Infectious Diseases.

1. Decide as to sending the patient to a hospital or treating the case in the house.

2. If a case for the hospital, apply for a special conveyance, and do not under any circumstances employ a public carriage.

3. After the removal of the infected person, fumigate and disinfect rooms occupied (*vide* foregoing instructions for disinfecting unoccupied rooms).

4. If a case for treatment at home, clear the house as far as possible of all inmates except the attendants on the sick, and secure the services of a trained nurse.

5. Remove carpets, curtains, and all superfluous furniture.

6. If small-pox, vaccinate every one in any way exposed to infection.

7. Allow as much fresh air as possible without creating draughts, and keep a good fire burning day and night in the room.

8. Use disinfectant solutions in all utensils and slop-pails. Place soiled clothes and linen in a disinfectant solution before they are taken from the room.

9. Open doors or windows are to be curtained with sheets kept moist with carbolic acid and water.

10. Drains, sinks, and closets to be flushed at least once a day with disinfectants.

11. Every room that has been occupied by an infected person should be thoroughly purified before it is re-occupied.

12. During convalescence patients should have tepid or warm baths, medicated with some suitable disinfectant, such as Condy's fluid or carbolic acid. This is very useful in cases of scarlet fever.

SECTION VIII.

MONEY, WEIGHTS, AND MEASURES OF ALL NATIONS—USEFUL RULES IN MENSURATION—LOGARITHMS, NATURAL SINES, TANGENTS, ETC.—FLOATING POWERS OF SPARS—RULES FOR CALCULATING TONNAGE OF VESSELS.

MONEY.

America, United States.

				English Value.
		1 Cent	=	½d.
100 Cents	=	1 Dollar	=	4s. 2d.
5 Dollars	=	1 Half Eagle	=	20s. 10d.
10 Dollars	=	1 Eagle	=	£2 1s. 8d.
20 Dollars	=	1 Double Eagle	=	£4 3s. 4d.

£1 sterling = 4 Dollars, 86 Cents, 6½ mils.

Argentine Confederation.

100 Centimes = 1 Dollar = 4s. 2d.

Silver coins—Dollar, and 50, 20, and 10 Centimo pieces.
Nickel coins—5 and 2 Cents. *Bronze coins* of 1 Cent.; and Paper dollar = 2d.

Austria.

100 Kreutzers = 1 Florin = 1s. 11¾d.

£1 sterling = 10 Florins, 28 Kreutzers.

Paper money is the chief medium of payment.

Belgium.

Decimal system (same as France).

Brazil.

Gold coins—20 Milreis = £2 5s.; 10 Milreis = £1 2s. 6d.
Silver coins—2 Milreis = 4s. 6d.

The value of a paper Milreis varies from 2s. to 2s 4d. sterling.

British India.

			English value.
12 Pies	=	1 Anna	= 1½d.
16 Annas	=	1 Rupee	= 2s. 0d.*
15 Rupees	=	1 Mohur	= £1 10s. 1d.

£1 sterling = 10 Rupees, 4 Annas.*

Lac of Rupees	=	100,000	= £10,000
Crore of Rupees	=	10,000,000	= £1,000,000*

The Independent States have each a separate coinage, all different.

Burmah.

4 Great Rweh (rees)	=	1 Bais	= 1½d.
4 Bais	=	1 Math	= 6d.
4 Maths	=	1 Tical	= 2s. 0d.

£1 sterling = 10 Ticals or Kyats.

Canada.

		1 Cent	= ½d.
100 Cents	=	1 Dollar currency	= 4s. 1½d.

£1 sterling = 4 Dollars 86⅔ Cents.

Cape of Good Hope.

Same as Great Britain. Accounts are still kept at times in Schillings = 2½d., and Rixdollars = 1s. 6d.

Chili.

100 Centavos	=	1 Dollar or Peso current	= about 3s. 9d.
10 Dollars	=	1 Condor	

There is a large paper currency in circulation.

China.

10 Cash	=	Candareen (Fan).	Value of *Cash* variable.
10 Candareens	=	1 Mace (Tsin)	= about 6d.
10 Mace (*see* page 367)	=	1 Tael (Leung)	

Established rate among Foreigners—Dollar = 4s. 2d.; Mexican dollar, 4s. 6d.

* This is the nominal value of the Rupee. As regards Indian pay and allowances and remittances to England, the sterling rate for the Rupee is fixed annually by the British Treasury. For the year 1881–2, it was 1s. 8d.

The only native coin in use in China is the *tsin*, called *cash* by the English, and *sapeque* by the French, who derive it from the Portuguese *sapeca*. It bears on one side the name of the province it is cast in, in Manchu letters, also the Chinese word "money;" and on the other side the name of the reigning Emperor, and above and below the words "current money" in Chinese characters. The value of *cash* fluctuates greatly. About 1200 to a Mexican dollar is an average quotation.

Spanish, Mexican, and South American dollars, though not acknowledged by the government, are employed as a commercial medium throughout the maritime provinces and at the interior treaty ports.

The nominal moneys of account are the *leung*, *tsin*, *fan*, and *li*, called by foreigners *tael*, *mace*, *candareen*, and *cash*, the proportion of which, one to the other, is decimal, but from various causes there is great diversity in the number of *cash* given in exchange for the *tael*. The terms *tael*, *mace*, *candareen*, and *cash*, are merely denominations of weight.

The circulating medium, in transaction with foreigners at the open ports, is chiefly in whole or broken dollars, clean or "chopped."* Lumps of stamped silver, called Sycee, pass current at a fixed standard of purity. The value of the dollar in relation to the *tael* is variable, the latter being approximately one third more. A *tael* of fine silver = 1800 *cash* = 6*s*. 8*d*.

Denmark.

			English value.
	1 Skilling . .	= a little more than	¼*d*.
96 Skilling . .	= 1 Rixdaler or Daler	=	2*s*. 2½*d*.
100 Öre . . .	= 1 Cröner	=	1*s*. 1*d*.

£1 sterling = 9 Rixdalers, 18 Skillings. 10 Cröner (gold piece) = 11*s*. 0½*d*.

East Coast of Africa (Mozambique).

(Same as Portugal.)

Egypt.

40 Paras . . .	= 1 Piastre	= 2½*d*.
100 Piastres . .	= 1 Lira, Egyptian	= £1 0*s*. 5*d*.

£1 sterling = 97½ Piastres.

(Same as Turkey, but coins of various nations are in circulation.)

* "Chopped" dollars are those which are stamped all over and defaced with innumerable private commercial (or hong) marks. "Clean" dollars have no mark or stamp whatever.

Falkland Islands.

(Same as Great Britain.)

France.

				English value.
100 Centimes	=	1 Franc	=	9½*d.*
20 Francs	=	1 Napoleon	=	15*s.* 10½*d.*

The par of exchange with London is about 25 Francs for £1 sterling.

Germany.

In December, 1871, one uniform system was introduced for all Germany; it is as follows:—10 Pfennings = 1 Groschen = 1·175*d.*; 10 Groschen, or 100 Pfennings = 1 Mark = 11¾*d.*

Gold Coins.—10 and 20 Mark pieces = respectively, 9*s.* 9½*d.* and 19*s.* 7*d.* Compared with the old system, the 10 Mark piece is equal to 3 Thalers 10 Silber Groschen of North German currency, or 5 Florins 50 Kreutzers of South German currency, or 8 Marks 5½ Schillings of Lubec or Hamburg customary currency, or 3 1·93rd Thalers of Bremen Gold reckoning.

Silver Coins.—During the period of transition the old silver coins of North Germany, down to the 5 Groschen piece, continue to be a legal tender, namely, the Thaler = 3 Marks = 2*s.* 11½*d.*; the Double Thaler = 6 Marks = 5*s.* 10½*d.*; the 10 Groschen piece = 1 Mark = 11¾*d.*; and the 5 Groschen piece = 5¾*d.*

Gibraltar.

16 Quartos	=	1 Real	=	4⅛*d.*
12 Reals	=	1 Dollar	=	4*s.* 2*d.*
100 Cents	=	1 Dollar	=	4*s.* 2*d.*

The Garrison accounts are kept in £ *s.* *d.*

Since May, 1872, the standard of value has been the Spanish "Doblon d'Isabel," and the moneys of account are as follows:—

10 Decimas de Real Vellon	=	1 Real Vellon	=	2½*d.*
20 Reals de Vellon	=	1 Dollar	=	4*s.* 2*d.*
100 Reals de Vellon	=	1 Doblon	=	£1 0*s.* 5*d.*

Gold Coins.—Doblon; 2 and 1 Dollars.

Silver Coins.—Dollar; Half-Dollar; 2, 1, and ½ Reals of Plate, the Real of Plate = 6*d.* sterling.

Base Silver Coin. — Peseta of 4 Reals Vellon = 9½*d.*; 2 and 1 Reals Vellon.

Bronze Coins.—Half Real Vellon; Cuartillo = ¾*d.*; and 2, 1, and ½ Decimas de Real Vellon.

Greece.

Decimal system (same as France).

			English value.
100 Lepta	=	1 Dracham	= 9½*d.*

Holland.

100 Cents	=	1 Guilder or Florin	= 1*s.* 8*d.*

£1 sterling = 12 Guilders or Florins.

Hong-Kong.

A legal tender in Hong-Kong consists of bank notes of one of the chartered banks; Hong-Kong or Mexican dollars; Spanish and South American dollars; Spanish quarter dollars and American silver, with shillings, sixpences, and francs. Value of the dollar fluctuates; Government rate of exchange, 4*s.* 3*d.*

India.

(See British India.)

Italy.

Decimal system (same as France).

100 Centimes	=	1 Lira	= 9½*d.*

Japan.

In 1871 a new Monetary System, based upon a gold standard, was introduced in Japan. The Yen, weighing 25·72 Troy grains of gold, $\frac{9}{10}$ fine, was constituted the fundamental unit of the system. The Yen, or dollar, is divided into 100 Sen, and the Sen into 10 Rin, as follows:—

10 Rin	=	1 Sen	= ½*d.*
100 Sen	=	1 Yen	average value, 4*s.*

Gold coins.—10, 5, and 2½ dollar pieces. *Silver coins.*—Dollar; 50, 20, and 5 cent pieces.

The Itsiboo was the coin in most common use, its intrinsic value being 1*s.* 4½*d.*

There is an extensive paper currency, but it is at a large discount.

Mauritius.

The unit of account and standard of value is the silver rupee of India. 100 cents = 1 rupee = 2*s.* nominally. English bronze is also a legal tender: 1*d.* = 4 cents.

Mexico.

		English value.
3½ Cents	= 1 Quartillo	
100 Cents	= 1 Dollar	= 4*s.* 2*d.*
15⅞ Dollars (about)	= 1 Doubloon	

New South Wales.

(Same as Great Britain.)

Norway.

24 Skillingen, or 100 Öre	= 1 Mark, Ort, or Cröner	= 1*s.* 1*d.*
5 Mark	= Species-Daler	= 4*s.* 5½*d.*
£1 sterling = 4½ Species-Dalers.	10 Cröner (gold piece)	= 11*s.* 0½*d.*

Portugal.

The unit of account is the Rei, worth $\frac{4}{10}$*d.* sterling.
A Cruzado = 400 Reis. A Cruzado Novo or Pinto = 480 Reis.
£1 sterling = 4500 Reis.

Russia.

100 Copecks	= 1 Silver Rouble	= 3*s.* 2*d.*
10 Roubles	= 1 Imperial	= £1 11*s.* 8*d.*

£1 sterling = 7 Roubles 31½ Copecks.

Paper money is the chief medium of payment. The paper Rouble is worth about 2*s.* 6*d.* sterling.

Siam.

4 P'hainungs	= 1 Fuang	= 3¾*d.*
2 Fuangs	= 1 Salung or Miam	= 7½*d.*
4 Salungs or Miam	= 1 Tical or Bat	= 2*s.* 6*d.*
4 Ticals	= 1 Tamlung	= 10*s.* 0*d.*

The Tical is a silver coin with the device of an elephant impressed, weighing 236 grains Troy.

Spanish dollars are largely in use, and are accepted at the rate of three dollars for five Ticals.

Singapore.

				English value.
100 Cents	=	1 Dollar	=	4s. 3d.

Spanish, Mexican, South American, Hong-Kong, and Japanese dollars are legal tenders.

Spain.

Decimal system (same as France).

		1 Centimo	= $\frac{12}{100}d.$
100 Centimos	=	1 Peseta	= $9\frac{1}{2}d.$

£1 sterling = 25 Pesetas.

St. Helena.

(Same as Great Britain.)

Sweden.

100 Öre	=	1 Riksdaler or Cröner	= 1s. 1d.
£1 sterling = 18 Riksdalers.		10 Cröner (gold piece)	= 11s. $0\frac{1}{4}d.$

Turkey.

40 Paras	=	1 Piastre	= $2\frac{4}{12}d.$
20 Piastres	=	1 Medjidie	= 3s. $5\frac{1}{2}d.$
100 Piastres	=	1 Lira Turca	= 18s. $0\frac{3}{4}d.$

West Coast of Africa.

British coin is taken anywhere on the coast, but after leaving Sierra Leone coppers are of no value.

On the Liberian coast United States coin is also in circulation, and Portuguese at St. Paul de Loando.

In the rivers the natives prefer cloth, etc., to money. The cowrie shell is still universally used inland. The scale of valuation as understood by the natives is—

40 Cowries of all sizes make 1 *string*.
40 *Strings* = 1 Head (common name for dollar).
20 Heads = 1 ounce of gold dust = £4.
2000 average Cowries weigh 5 lbs.

WEIGHTS AND MEASURES.

The United Kingdom of Great Britain and Ireland.

The Standard for measures of length is a pendulum vibrating seconds of time in a vacuum at the level of the sea, in the latitude of London, at a temperature of 62° Fahr., whose length is divided into 391·393 equal parts; 360,000 of these parts is the length of the English yard.

I.—Imperial Measures of Length.

12 Inches	=	1	Foot
3 Feet	=	1	Yard
5½ Yards	=	1	Rod, Pole, or Perch
4 Poles, or 100 Links, or 66 Feet	=	1	Chain
40 Perches or 10 Chains	=	1	Furlong
8 Furlongs, or 1760 Yards	=	1	Mile
3 Miles	=	1	League

The Fathom = 6 Feet; a Cable's Length = the tenth of a Sea Mile, or about 200 Yards; the Nautical Mile or Admiralty Knot = 6080 Feet = 1·151 Statute Miles = 1853 Metres.

Length of European measures of distances, or miles; compared with the English Statute Mile of 5280, and Nautical Mile of 6080 Feet.

	Length in Statute miles.	Length in Nautical miles.
English Statute Mile	1·000	0·869
English Nautical Mile	1·151	1·000
Austrian Mile	4·714	4·095
Danish Mile	4·681	4·067
French Kilometre	0·621	0·539
German Geographic Mile	4·604	4·000
German Ruthen	4·681	4·067
Italian Mile	1·151	1·000
Norwegian Mile	6·922	6·014
Russian Verst	0·663	0·574
Swedish Mile	6·623	5·754

II.—Imperial Measures of Surface.

144 Square Inches	=	1	Square Foot
9 „ Feet	=	1	„ Yard
30¼ „ Yards, 272¼ Sq. Feet	=	1	„ Rod, Pole, or Perch
40 Poles	=	1	Rood

4 Roods, 4840 Sq. Yards, 10 Sq. Chains, or 100,000 Sq. Links.	=	1 Acre
100 Acres	=	1 Hide of Land
640 Acres	=	1 Sq. Mile

III.—IMPERIAL MEASURES OF CUBIC CAPACITY.

1728 Cubic Inches	=	1 Cubic Foot
27 Cubic Feet	=	1 Cubic Yard

The Imperial Gallon is the standard of capacity for both wet and dry goods, and has a cubic content of 277·274 cubic inches, and contains 10 lbs. Avoirdupois of distilled water at a temperature of 62° Fahr. It is convenient to remember that a cubic foot of water weighs *about* 1000 ounces Avoirdupois.

IV.—IMPERIAL MEASURES OF CAPACITY FOR LIQUIDS.

8·665 Cubic Inches	=	1 Gill
4 Gills	=	1 Pint
2 Pints	=	1 Quart
4 Quarts	=	1 Gallon

V.—IMPERIAL MEASURES OF CAPACITY FOR DRY GOODS.

2 Pints	=	1 Quart
4 Quarts	=	1 Gallon
2 Gallons	=	1 Peck
4 Pecks (8 gallons)	=	1 Bushel
8 Bushels	=	1 Quarter

VI.—MEDICAL SUBDIVISIONS OF THE IMPERIAL PINT.

60 Minims	=	1 Fluid Drachm (f. ʒ)
8 Fluid Drachms	=	1 Fluid Ounce (f. ℥)
20 Fluid Ounces	=	1 Imperial Pint (O)
8 Pints	=	1 Gallon

VII.—TROY WEIGHT.

The unit and only standard of weight is the Imperial Troy pound, consisting of 5760 grains. The pound Avoirdupois (lb.) contains 7000 Troy grains. A cubic inch of distilled water weighed in air by brass weights at a temperature of 62° Fahr., barometer at 30 inches, will weigh 252·458 grains Troy; about 10½ pennyweights Troy, or about 9⅛ drams Avoirdupois.

				Metric equivalent. Grammes.
24 Grains	=	1 Pennyweight	(dwt.)	= 1·555176
20 Pennyweights	=	1 Ounce	(oz.)	= 31·10352
12 Ounces	=	1 Pound (5760 grains)	(lb.)	= 373·24224

This weight is used for gold, silver, and precious stones, and in philosophical experiments.*

VIII.—AVOIRDUPOIS WEIGHT.

27 11/32 Troy Grains	=	1	Dram (dr.)
16 Drams	=	1	Ounce (oz.)
16 Ounces (or 7000 Troy Grains)	=	1	Pound (lb.)
14 Pounds	=	1	Stone
28 Pounds	=	1	Quarter (qr)
4 Quarters (or 112 lbs.)	=	1	Hundredweight (cwt.)
20 Hundredweight	=	1	Ton

This weight is used in almost all commercial transactions.

OLD APOTHECARIES' WEIGHT.

20 Grains	=	1 Scruple	=	20 Grains	Troy
3 Scruples	=	1 Drachm	=	60 „	„
8 Drachms	=	1 Ounce	=	480 „	„
12 Ounces	=	1 Pound	=	5760 „	„

Apothecaries compounded by this weight, but bought and sold their drugs by avoirdupois.

NEW APOTHECARIES' WEIGHT.

Introduced in 1864.

Ounce	=	437½ Grains
Pound, 16 Ounces	=	7000 „

Same as Avoirdupois.

Water and Provisions.

Ton	= 210 Gallons	Weigh	2100 lbs.
Butt	= 110 „	„	1100 „
Puncheon	= 72 „	„	720 „
Barrel	= 36 „	„	360 „
Kilderkin	= 18 „	„	180 „

* *Weight of Coins.*—A half-crown weighs, new, ½ oz., a florin ⅖ oz., a shilling ⅕ oz., a sixpence 1/10 oz., a fourpenny-piece 1/15 oz., and a threepenny-bit 1/20 oz. Penny, halfpenny, and farthing weigh respectively ⅓, ½, and 1/10 oz. The following is the exact weight in grains of the various coins:—Sovereign, 123·2745; half-sovereign, 61·6372; half crown, 218·182; florin, 174·545; shilling, 87·273; sixpence, 43·636; fourpenny-piece, 29·091; threepenny-bit 21·818; penny, 145·833; halfpenny, 87·500; farthing, 43·750. The intrinsic value of the silver money is 22 shillings, equivalent to one sovereign; of the bronze, 480 pennies, also equivalent to one sovereign.

Tanks.

	No.	Galls.	Length. Ft.	In.	Breadth. Ft.	In.	Depth. Ft.	In.
Whole	1	600	4	1	4	1	6	1
„	2	500	4	1	4	1	5	1
„	3	400	4	1	4	1	4	1
Half	4	200	4	1	2	1	4	1
„	5	200	4	1	4	1	2	1
„ corner off	6	193	4	1	4	1	2	1
„	7	200	3	3	3	3	3	3
Quarter	8	100	3	3	1	8	3	3
„	9	100	3	3	3	3	1	9
Bilge	10	375	4	1	4	1	4	1
„	11	264	4	1	3	7	4	1
„	12	110	3	3	2	7	2	10

Provisions.

Biscuit	Bags	112 lbs.
Rum	Puncheon	72 gallons
	Hogshead	54 „
	Barrel	36 „
	Half-hogshead	25 „
	Kilderkin	18 „
	Small cask	12 „
Salt Beef	Tierce	38 8-lb. pieces
	Barrel	26 „ „
Salt Pork	Tierce	80 4-lb. pieces
	Barrel	52 „ „
Flour	Barrel	336 lbs.
	Half-hogshead	250 „
Suet	Half-hogshead	168 „
	Small cask	70 „
	Ditto	56 „
Raisins	Barrel	336 „
	Half-hogshead	224 „
	Small cask (Firkin)	112 „

Peas	Barrel	5 bushels = 40 gallons
	Half-hogshead	3½ bushels = 28 „
Oatmeal	Barrel	7½ „
	Half-hogshead	5½ „
	Small cask	2½ „
	Ditto	2 „
Sugar	Barrel	392 lbs.
	Half-hogshead	280 „
	Small cask	112 „
Chocolate	Half-hogshead	108 „
	Small cask	55 „
Tea	Chest	83 „
	Half-chest	36 „
Vinegar	Puncheon	72 gallons
	Hogshead	54 „
	Barrel	36 „
	Half-hogshead	25 „
	Kilderkin	18 „
	Small cask	12 „
Tobacco	Hogshead	242 lbs.
	Barrel	160 „
	Half-hogshead	126 „
Soap	Half-hogshead	113 „
	Barrel	244 „

A fathom of firewood is 2 ft. high and 6 ft. square.

India (Bengal).

The Indian Weights and Measures vary in every district, but English equivalents are coming into use in large towns.

Guz (average)	=	36 English Inches.
Bám or Danda (Fathom)	=	2 English Yards.
Coss = 1000 Dandas	=	1·136 Statute Miles.*

* The Coss varies in different parts of India from one to three statute miles.

WEIGHTS.

Tola, the unit of postage, = 180 Grains Troy. 5 Tolas = 1 Chittâk. 16 Chittâks = 1 Ser = $2\frac{2}{35}$ lbs. Av. 40 Sers = 1 Imperial or Indian Maund = $82\frac{2}{7}$ lbs. Av. The factory Maund = $74\frac{2}{3}$ lbs. Av.

For weighing gold and silver the Tola is divided into 12 Machas. Pure gold or silver is said to be 12 Machas fine.

In 1871 the "Ser" = 1 Kilogramme was made the primary standard of weight.

LIQUID MEASURE.

Maund = 8 Palli = 9·81 British Imperial gallons.

Madras.

The English Foot and Yard are now used by almost all native workmen. The Native Guz = 33 English Inches. The Baum or Fathom = $6\frac{1}{2}$ English Feet. A Kâdam = 10 English Miles.

WEIGHTS.

The Viss = 3·09 lbs., the Maund 24·69 lbs., and the Candy 493·71 lbs. English Av.

Bombay.

LENGTH.

Guz = 27 English inches.

The weights given under the head of Bengal are being introduced.

CAPACITY.

The old weights in common use are the Candy of 20 Maunds = 560 lbs. Av. The Candy for cotton is 28 Maunds = 7 cwt.

Canada.

The Metric System has been legalized as permissive.

(Same as Great Britain.)

Mauritius.

The Metric System is in operation.

(Same as Great Britain.)

West Indies (British).

(Same as Great Britain.)

Gibraltar.

(Weights and Measures chiefly those of Great Britain.)

Cape of Good Hope.

Weights and Measures in use are partly those of Great Britain, and partly the old Dutch measures.

Rheinland Fuss = 1·03 Feet. The Aam of 2 Ankers, of 2 Steeknen, of 8 Stoopen, of 2 Meugeln, of 2 Pintjes, of 4 Maajes = 34·16 British Imperial Gallons.

The old Amsterdam Pfund = 1·32 Troy lbs. or 1·09 lbs. English Av. 92 old Amsterdam Pfund = 100 lbs. English Av.

France.

The *Metre* is the fundamental unit of the measures of length as well as of all weights and measures. It is the ten-millionth part of the distance from the Pole to the Equator.

The French weights and measures are given in full as a representative of the Metric system.

Measures of Length.

(Of which the *Metre* is the element.)

					English value. Inches.
1000th part of a Metre	=	1 Millimetre	=		·03
100th ditto	=	1 Centimetre	=		·39
10th ditto	=	1 Decimetre	=		3·93
	1 Metre	=	39·371 inches	=	3·281 Feet
10 Metres	=	1 Decametre	=	32·809 feet	=	10·936 Yards
100 „	=	1 Hectometre	=	328·09 yards	=	109·363 „
1000 „	=	1 Kilometre	=	1093·63 „	=	0·621 Mile
10,000 „	=	1 Myriametre	=	10,936·33 „	=	6·214 „

The Kilometre is sometimes termed a Metrical Mile. The mean Nautical Mile = 1853 Metres = 1·1507 Statute Miles. The Marine League = $\frac{1}{20}$ Degree = 5560 Metres. Toise = 2 Metres = 6·56 Feet.

MEASURES OF SURFACE.

(Of which the *Are* is the element.)

										Square inches.
100	Square	Millimetres	.	=	1	Square	Centimetre	.	=	·155
100	„	Centimetres	.	=	1	„	Decimetre	.	=	15·500
										Square feet.
100	„	Decimetres	.	=	1	Centiare or square	Metre	.	=	10·764
										Square yards.
100	„	Metres	.	=	1	Are or square	Decametre	.	=	119·603
										English value. Acres.
10	Square	Ares	.	=	1	Decare			=	0·247
100	„	Decametres	.	=	1	Hectare			=	2·471
100	„	Hectares	.	=	1	Square	Kilometre	.	=	247·113
100	„	Kilometres	.	=	1	„	Myriametre	.	=	24711·340

CUBIC OR SOLID MEASURES.

(Of which the *Stere* or Cubic Metre is the element.)

										Cubic feet.
10th of a	Stere	.	=	1	Decistere				=	3·532
10	Decisteres	.	=	1	Stere	.			=	35·317
10	Steres	.	=	1	Decastere	.			=	353·166

MEASURES OF CAPACITY.

(Of which the *Litre*, a Cubic Decimetre, is the element.)

										Minims.
1000th of a	Cubic	Decimetre	=	1	Millilitre				=	16·903
										Fluid drachms.
10	Millilitres	.	=	1	Centilitre				=	2·817
										Imperial pints.
10	Centilitres	.	=	1	Decilitre				=	·176
10	Decilitres	.	=	1	Litre	.			=	1·761
										Imperial gallons.
10	Litres	.	=	1	Decalitre				=	2·201
										Imperial bushels.
10	Decalitres	.	=	1	Hectolitre				=	2·751
10	Hectolitres	.	=	1	Kilolitre				=	27·512

TABLE OF WEIGHTS.

(Of which the *Gramme*, a Cubic Centimetre of distilled water weighed *in vacuo* at a temp. of 39° Fahr., is the element.)

					Grains (Troy).
1000th of a Gramme	=	1 Milligramme	=		·015
10 Milligrammes	=	1 Centigramme	=		·154
10 Centigrammes	=	1 Decigramme	=		1·543
10 Decigrammes	=	1 Gramme	=		15·432
10 Grammes	=	1 Decagramme	=		154 323
				lbs. oz.	drs. av.
10 Decagrammes	=	1 Hectogramme	=	0 3	8·438
10 Hectogrammes	=	1 Kilogramme	=	2 3	4·383
					English value. lbs. av.
10 Kilogrammes	=	1 Myriagramme	=		22·047
10 Myriagrammes	=	1 Quintal Metrique	=		220·466
10 Quintals	=	1 Ton or Millier	=		2204·66

Spain, Portugal, Belgium, and Italy.

(The Weights and Measures are the same as those of France.)

Brazil.

Same as France, but the following are found:—

Gold and silver weight—1 Marco = 3545 Grains Troy; Commercial pound, Libra = 1·02 lb. Av.; 1 Moyo = 23·39 bushels; 1 Almuda = 3 6407 Gallons, and 1 Foot = 12·944 inches.

Holland.

(Same as France.)

Elle = Metre. Palm = Decimetre. Duim = Centimetre. Streep = Millimetre. Roede = Decametre. Mijle = Kilometre. Bunder = Hectare. Kan and Kop = Litre. Maajte = Decilitre. Vingerhoed = Centilitre. Scheppel = Decalitre. Vat or Ton, and Mud or Zak = Hectolitre. Last = Kilogramme. Ons = Hectogramme. Lood = Decagramme. Wigtje = Gramme. Korrel = Decigramme.

Greece.

(Same as France.)

Pecheus = Metre. Palame = Decimetre. Daktylus = Centimetre. Gramme = Millimetre. Stadion = Kilometre. Skoinis = Myriametre. Stremma =

Are. Koilon = Hectolitre. Litra = Litre. Kotyle = Decilitre. Mystron = Centiletre. Kybos = Millilitre. Mnâ = 1½ Kilogramme. Drachme = Gramme. Obolos = Decigramme. Kokkos = Centigramme. Tonos = 29·5 English cwt.

Argentine Republic.

Same as France, but they are not yet in general use. The following are commonly met with:—

1 Pie = 12 Pulgadas = 11·36 English Inches.
1 Braza = 6 Pies = 5·68 „ Feet.
The English Yard is also used.
1 Libra = 12 Onzas = 1·01 lbs. Av.

United States of North America.

In 1866 the Metric System was legalized as permissive.

The measures of *Length*, *Distance*, *Surface*, and *Solidity* are the same as those of Great Britain The weights also are the same; but articles formerly sold by the cwt. are now generally sold by the Centner or Quintal of 100 lbs. Av. 20 Centners = 1 Ton.

For Dry Goods, the Gallon = ·969 Imperial Gallon; and the Bushel = ·96 Imperial Bushel. For Liquids, the Gallon = ·833 Imperial Gallon.

Germany (North).

Prussia.

The Metric System becomes compulsory for the whole German Empire from January 1st, 1872. The old system was as follows:—

MEASURES OF LENGTH.

			English value.
12 Linien	= 1 Zoll	=	1·029 Inches
12 Zoll	= 1 Fuss	=	12·356 „
2 Fuss	= 1 Elle	=	2·06 Feet
12 Fuss	= 1 Ruthe	=	4·12 Yards
2000 Ruthen	= 1 Meile	=	4·68 Miles

MEASURE OF CAPACITY (DRY GOODS).

16 Metzen	= 1 Scheffel	=	1·51 Bushels

MEASURE OF CAPACITY (LIQUIDS).

2 Ossel	=	1 Quart		=	1 Quart		
60 Ossel	=	1 Anker		=	7·56	Gallons	
2 Ankers	=	1 Eimer		=	15 12		„
2 Eimers	=	1 Ohm		=	30·24		„

WEIGHTS.

10 Corn	=	1 Cent	=	·094	Drams	Av.
10 Cents	=	1 Quentche	=	·941		„
10 Quentchen	=	1 Loth	=	9·406		„
30 Loth	=	1 Zollpfund	=	1·102	lbs.	Av.
100 Zollpfund	=	1 Centner	=	110·232		„

Russia.

LENGTH.

The English Foot is the standard. Sashine = 7 Feet. Verst = 0·66 Mile.
The Marine Sashine = the English Fathom.

CAPACITY (LIQUIDS).

Tscharkey = ·86 of a Gill. Vedro = 2·7 Gallons. Anker = 8·11 Gallons.

CAPACITY (DRY GOODS).

Pajak = 1·44 Bushels.

WEIGHTS.

Lana = 1½ oz. Av. Funt (Pound) = 14½ oz. Av.
Pud (or Pood = 1 qr. 8 lbs. Av. Berkovitz = 3 cwt. 0 qrs. 25 lbs.

Austria.

LENGTH.

Zoll = 1·04 Inch. Fuss = 1·04 Foot. Elle = 2·07 Feet.
Klafter = 6·22 Feet. Meile = 4·71 Miles.

CAPACITY (DRY GOODS).

Metze = 1·69 Bushel.

CAPACITY (LIQUIDS).

Kanne	=	1·25 Pint.	Mass	=	1·25 Quart.
Viertel	=	3·11 Gallons.	Eimer	=	12·46 Gallons.

WEIGHTS.

Quentchen	= 2·47 Drachms.	Unze	= 1 oz. 3·7 dr.
Pfund	= 1·23 lb. Av.	Centner	= 123·47 lbs. Av.

Sweden.

(The Decimal System has been introduced.)

LENGTH.

Fot = 11·66 Inches. Famn = 5·843 Feet.
Mil = 6·62 Miles.

WEIGHTS.

Skälpund = ·938 of a lb. Av. Centner = 83·72 lbs.

Norway.

LENGTH.

(The Decimal System has been introduced.)
Fod = 12·36 Inches. Favn = 6·175 Feet.

Denmark.

LENGTH.

Fod = 12·36 Inches. Favn = 6·175 Feet. Miill. = 4·68 Miles.

WEIGHTS.

Pund = 1·102 lb. Av. Centner = 110·23 lbs. Av.

Turkey.

LENGTH.

Pike or Drâ = 27 Inches. Berri = 1·04 Mile.

WEIGHTS.

Rottolo = 1·24 lb. Av. Cantar = 124·7 lbs. Av. Oke = 2·83 lbs. Av.

Egypt.

LENGTH.

Pike Draâ = 27 Inches. Gasab = 8·5 Feet.

WEIGHT.

Cantar of 100 Rottolos = 98·05 lbs. Av.

China.

Measures of Length.

The *Li* is generally estimated by foreigners to be about one-third of Geographical Mile.

1 Grain	. .	=	1 Fun		
10 Fun	. .	=	1 Tsun or Inch	=	1·41 Inch
10 Tsun	. .	=	1 Chih or Foot	=	14·1 Inches
10 Chih	. .	=	1 Chang or Pole	=	11·75 Feet
10 Chang	. .	=	1 Yin		

Measures of Capacity.

1 Grain of Millet		=	1 Suh		
6 Suh	. .	=	1 Kwei		
10 Kwei	. .	=	1 Tsoh		
10 Tsoh	. .	=	1 Chau or Handful		
10 Chau	. .	=	1 Choh or Ladle		
10 Choh or 2 Yoh		=	1 Koh or Gill	=	0·103 Litre
10 Koh	. .	=	1 Shing or Pint	=	1·031 „
10 Shing	. .	=	1 Tau or Peck	=	10·310 Litres

Commercial Weights.

The unit of the table is the *Liang* or *Tael*.

1 Kernel of Millet	. . .	=	1 Shu
10 Shu	. . . . .	=	1 Lui
10 Lui	. . . . .	=	1 Chu or Pearl
20 Chu	. . . . .	=	1 Liang or Tael
1 Tael = 1·333 oz. Av.	. .	=	37·796 Grammes

Also, 16 Liang or Taels	=	1 Kin or Catty	=	1⅓ lbs. Av.	
2 Kin	. .	=	1 Yin . .	=	2⅔ „
30 Kin	. .	=	1 Kiun . .	=	40 „
100 Kiun	. .	=	1 Tan or Picul	=	133⅓ „
120 Kin	. .	=	1 Shih or Stone	=	160 „

The Picul and Catty are chiefly used in dealings with foreigners

The following equivalents will be found useful :—

1 Ton	. .	=	16 Piculs, 80 Catties.
1 Cwt.	. .	=	84 Catties.
1 lb. Av.	.	=	$\frac{3}{4}$ of a Catty or 12 Taels.
4 Ozs.	. .	=	3 Taels.
1 Picul	.	=	1·19047 Cwt.
3000 Taels	.	=	302 lbs. Troy.

Chinese weights and grain measures, also the linear long and land measures, all vary in different parts of the country, but as a general rule they are largest and longest in the southern provinces.

The difference in the values of the weights above a tael, as fixed by treaty, and those in common use in China, are as follows :— *

	British Treaty.	French Treaty.	Common Weights.
Tael	1·333 oz. Av.	37·783 grammes.	1·328 oz. Av.
Catty	1·333 lbs. Av.	604·53 „	1·326 lbs. Av.
Picul	133·33 „	60·453 kilogr.	132·6 „
Stone	159·99 „	72·544 „	159·1 „

For Weighing Gold, Silver, and Medicines.

10 Cash = 1 Fan. 10 Fan = 1 Tsin. 10 Tsin = 1 Tael = 579·8 grs. Troy.

Japan.

Length.

Shaiku = the English Foot. Ken = the English Fathom.
Ri = 36 Chō = 2½ Miles.
The English yard is the common measure of length.
The Chō (land measure) = 2½ Acres.

Weights.

Tael (ichi nomme) = 2·13 drs. Av. Catty (ikkin) = 1·33 lbs. Av.
Picul (hiak-kin) = 100 Catties = 133·33 lbs. Av.

Note.—For a detailed explanation of the Money, Weights, and Measures of all countries, see the *Merchant's Handbook*, by W. A. Browne, LL.D., Stanford, Charing Cross.

* This information is taken from the *Chinese Commercial Guide*, by S. Wells Williams.

Provisions allowed for the undermentioned Number of Men and Days, showing the Gross Weight and Measurement.

ARTICLE.	500 MEN FOR 90 DAYS.							800 MEN FOR 10 DAYS.						
	Quantity.	Packages. Barrels.	Half Hgsheds.	Small Casks.	Cases.	Gross Weight.	Measurement.	Quantity	Packages. Barrels.	Half Hgsheds.	Small Casks.	Cases.	Gross Weight.	Measurement.
						lbs.	Cb. Ft						lbs.	Cb. Ft
Biscuit.....lbs.	56250	563	*bags*			57376	2812 5/12	10000	100	*bags*			10200	500
Rum.....galls.	703	19	..	1	..	8214	195	125	3	..	1	..	1559	37
Sugar.....lbs.	5625	14	..	1	..	6668	145	1000	2	1	..	..	1239	27
Chocolate.....lbs.	2812	..	..	..	29	3396	64 1/12	500	..	..	..	5	595	11 5/12
Tea.....lbs.	703	..	..	..	7	847	35	125	..	..	..	2	187	8
Pork.....lbs.	22500	75	..	..	..	39750	750	4000	12	2	..	..	7080	134
Peas.....lbs.	7500	23	..	1	..	8794	235	1333	4	..	..	..	1496	40
Celery Seed.....lbs.	29	..	..	..	1	52	1	6	..	..	..	1	7	1/12
Salt Beef.....lbs.	11250	37	1	..	..	19970	377	2000	6	1	..	..	3540	67
Flour.....lbs.	6318	19	..	..	..	7258	190	1125	3	..	1	..	1278	34
Suet.....lbs.	526	..	..	5	..	1275	25	94	..	..	1	..	181	4
Raisins.....lbs.	1053	..	..	..	10	1780	40	188	..	..	..	2	340	8
Oatmeal.....lbs.	1212	..	..	8	..	1616	40	216	..	1	..	..	289	7
Mustard.....lbs.	202	..	..	..	2	266	7 5/12	36	..	..	..	1	73	2
Pepper.....lbs.	101	..	..	..	2	146	4	18	..	..	..	1	36	1
Vinegar.....galls.	202	..	8	..	..	2536	80	36	1	..	..	..	450	10
Boiled Beef.....lbs.	8438	..	..	..	234	12870	390	1500	..	..	..	42	2310	63
Preserved Potatoes lbs.	1406	..	..	..	14	1988	60 1/12	250	..	..	..	3	346	10 1/12
Rice.....lbs.	1407	..	6	..	..	1854	42	250	..	1	..	..	309	7
Lemon Juice.....lbs.	375	..	..	..	10	930	20	62	..	..	..	2	186	4
Candles.....lbs.	2700	..	..	..	54	3348	81	750	..	..	..	15	930	22 1/12
Tobacco.....lbs.	1800	11	..	1	..	2650	125	300	2	..	..	..	458	20
Soap.....lbs.	4050	..	..	..	41	5022	108 1/12	800	..	..	..	8	992	21 1/12
						188606	5828						34081	1039

Provisions allowed for the undermentioned Number

ARTICLE.	100 MEN FOR 1 DAY.								8	
	Quantity.	Packages.				Total Weight.	Measurement.	Quantity.	Barrels.	
		Barrels.	Half-Hogsheads.	Small Casks.	Cases.					
							Cubic feet			
Biscuit .. .. .. lbs.	125	—	—	—	—	—	—	10000	20	
Rum .. .. .. galls.	$1\frac{25}{32}$	—	—	—	—	—	—	125	—	
Sugar .. .. .. lbs.	$12\frac{5}{16}$	—	—	—	—	—	—	1000	—	
Chocolate .. .. lbs.	$6\frac{4}{16}$	—	—	—	—	—	—	500	—	
Tea .. .. .. lbs.	$1\frac{9}{16}$	—	—	—	—	—	—	125	—	
Pork .. .. .. lbs.	50	—	—	—	—	—	—	4000	—	
Split Peas .. .. lbs.	$16\frac{7}{8}$	—	—	—	—	—	—	1333	—	
Celery Seed .. .. lbs.	$0\frac{1}{16}$	—	—	—	—	—	—	6	—	
Salt Beef .. .. lbs.	25	—	—	—	—	—	—	2000	—	
Flour .. .. .. lbs.	$14\frac{1}{16}$	—	—	—	—	—	—	1125	—	
Suet .. .. .. lbs.	$1\frac{11}{16}$	—	—	—	—	—	—	94	—	
Raisins .. .. .. lbs.	$2\frac{11}{16}$	—	—	—	—	—	—	188	—	
Oatmeal .. .. lbs.	$2\frac{7}{16}$	—	—	—	—	—	—	216	—	
Mustard .. .. lbs.	$\frac{2}{16}$	—	—	—	—	—	—	36	—	
Pepper .. .. .. lbs.	$\frac{1}{16}$	—	—	—	—	—	—	18	—	
Vinegar .. .. .. gall.	$\frac{2}{16}$	—	—	—	—	—	—	36	—	
Boiled Beef or Mutton ..	$13\frac{2}{16}$	—	—	—	—	—	—	1500	—	
Preserved Potatoes or Rice lbs.	$6\frac{4}{16}$	—	—	—	—	—	—	250	—	
Rice or Potatoes, of each lbs.	$7\frac{7}{16}$	—	—	—	—	—	—	250	—	
Lemon Juice (if issued) .. lbs.	$3\frac{4}{16}$	—	—	—	—	—	—	62	—	
Candles .. .. .. lbs.	6	—	—	—	—	—	—	500	—	
Tobacco .. .. .. lbs.	4	—	—	—	—	—	—	320	—	
Soap .. .. .. lbs.	9	—	—	—	—	—	—	700	—	
TOTALS ..										

Days, shewing the Gross Weight and Measurement.

Measurement.	100 Men for 90 Days. Quantity.	Packages. Barrels.	Half-Hogsheads.	Small Casks.	Cases.	Total Weight.	Measurement.	200 Men for 90 Days. Quantity.	Packages. Barrels.	Half-Hogsheads.	Small Casks.	Cases.	Total Weight.	Measurement.
Cubic feet						lbs.	Cubic feet						lbs.	Cubic feet
500	11250	{ according to stowage				11474	562 6/12	22500	{ according to stowage				23000	1125
35	140	—	6	—	—	1776	42	281	—	11	—	—	3256	77
30	1125	—	—	7	—	1596	35	2250	—	8	—	—	2724	56
12 6/12	562	—	—	—	11	704	13 9/12	1125	—	—	—	13	1492	26 9/12
9	140	—	—	—	3	198	9	281	—	—	—	3	363	15
140	4500	—	22	1	—	8122	158	9000	10	30	—	—	16100	310
45	1500	—	—	9	—	1728	45	3000	—	13	—	—	3497	91
1 6/12	6	—	—	—	1	7	1 6/12	12	—	—	—	1	14	1 12
70	2250	—	11	1	—	4162	81	4500	7	12	—	—	7310	154
35	1270	—	—	8	—	1624	40	2531	—	11	—	—	3113	77
5 10/12	105	—	—	2	—	268	5 10/12	211	—	—	5	—	670	14 7/12
5 4/12	210	—	—	—	2	340	8	422	—	—	—	4	680	16
10	240	—	—	2	—	264	8	480	—	—	4	—	528	16
2	40	—	—	—	1	73	2	80	—	—	—	2	146	4
2	20	—	—	—	1	73	2	40	—	—	—	1	73	2
11 6/12	40	—	—	3	—	588	12 10/12	80	—	—	5	—	1048	22 11/12
70	1688	—	—	—	47	2585	78 4/12	3376	—	—	—	94	5170	156 7/12
10	281	—	—	—	6	385	12	562	—	—	—	6	775	23 9/12
10	281	—	—	4	—	520	16	562	—	—	6	—	780	24
4	78	—	—	—	2	186	4	156	—	—	—	4	372	8
15	540	—	—	—	11	682	16 6/12	1080	—	—	—	22	1364	33
20	360	—	—	5	—	610	25	720	5	—	—	—	1145	50
19 10/12	810	—	—	—	—	992	22 9/12	1620	—	—	—	17	2046	44 7/12
1062 6/12						38957	1200						75666	2346 1/12

FOR HOME STATION.

Average Quantity of Clothing for 100 Men for 90 Day

Article.	Quantity.	Packages.		Weight.	Measurement.
		Bales.	Casks.		
				lbs.	Cubic Feet.
Blue Cloth, No. 1 .. yds.	37	1	—	56	2
Duck .. .. .. ,,	300	1	—	200	4
Coaling Duck .. .. ,,	150	1	—	101	2
Flannel .. .. ,,	210	1	—	75	4
Serge .. .. .. ,,	320	2	—	182	8
Drill .. .. .. ,,	150	1	—	73	2
Jean .. .. .. ,,	30	1	—	13	$\frac{1}{2}$
Stockings .. .. pairs	10	1	—	—	$\frac{1}{2}$
Shoes .. .. .. ,,	50	—	1	137	7
Half Boots .. .. ,,	50	—	1	168	10
Combs .. .. .. No.	12	—	—	—	—
Towels .. .. .. ,,	12	1	—	—	—
Blankets .. .. ,,	12	1	—	62	4
Beds .. .. .. ,,	4	—	—	34	5
Bed Covers .. .. ,,	12	1	—	29	1 $\frac{1}{2}$
Shirts .. .. .. ,,	25				
Handkerchiefs .. ,,	50	1	—	4	$\frac{1}{2}$
Sou'-Westers .. .. ,,	6	1	—	—	1
Materials for Trousers ,,	25				
Marks of Distinction ,,	—	—	—	—	
G. C. Badges .. .. ,,	—	1	—	—	
Marine Necessaries .. ,,	—	—	—	—	

IRON TANKS AND CASKS.

Capacity in Gallons.	Weight when Empty.			Measurement in Cubic Feet.		Capacity in Gallons.	Weight when Empty.			Measurement in Cubic Feet.	
Tanks.	cwt.	qrs.	lbs.	ft.	in.	Tanks.	cwt.	qrs.	lbs.	ft.	in.
600	10	1	14	98	3	375	6	2	25	61	8
500	8	2	16	82	0	264	5	2	2	43	9
400	6	3	25	65	8	110	3	0	6	18	9
						Casks.					
200	4	2	25	33	2	27	0	2	29		
193	5	1	20	32	4	13	0	1	12		
100	2	3	20	16	6	7	0	1	8		

To calculate the capacity of a cask, multiply half the sum of the areas of the two inferior circles, viz. at the head and bung, by the interior length, for the contents in cubic inches; which, divided by 277·27 (the number of cubic inches in a gallon), reduces the result to that measure.

In calculating the floating powers of casks, the weight of the casks themselves need not be taken into consideration, as when they are submerged, it is inappreciable.

USEFUL RULES IN MENSURATION.

I.—*To find the circumference of a circle, the diameter being given, and* vice versâ.

1. Multiply the diameter by 3·1416, the result will be the circumference.
2. Divide the circumference by 3·1416, and the result will be the diameter.

II.—*To find the area of a circle, the diameter being given, and* vice versâ.

1. Multiply the square of the diameter by ·7854. Result—area.
2. Divide the area by ·7854, and take the square root of the quotient, the result will be the diameter.

III.—*To find the surface of a cylinder, the diameter and length being given.*

Multiply the diameter by 3·1416 to get circumference of the section, and again multiply this product by the length.

IV.—*To find the volume of a cylinder, the diameter and length being given.*

Multiply the square of the diameter by ·7854, to get the area of the section, and then multiply this area by the length.

V.—*To find the surface of a sphere.*

Multiply the diameter of the sphere by its circumference, and its product will be the surface.

VI.—*To find the volume of a sphere.*

Multiply the cube of the diameter by ·5236, and the product will be the volume required.

VII.—*To find the volume of a cone.*

Proceed as in IV., and divide the result by three.

VIII.—*To find the area of an ellipse.*

Multiply the greatest and least diameters together, and that product by ·7854, the result will be the area.

IX.—*To find the circumference of an ellipse.*

Multiply half the sum of the two diameters by 3·1416, and the result will give the circumference sufficiently accurate for practice.

X.—Area of a triangle = ½ base, multiplied by the perpendicular.

XI.—Square inches divided by ·7854 = circular inches. Circular inches multiplied by ·7854 = square inches.

To find the Weight of a known Substance of given Dimensions.

Having found the volume, if the result be in cubic feet, multiply by the weight of a cubic foot; but if the volume be in cubic inches, multiply by weight of a cubic inch and divide the product so obtained by 1728.

Area of a square = square of one side.
Side of a square = square root of area.

Area of a parallelogram = length × perpendicular breadth.

Square inches	×	·007	=	square feet
Cubic inches	×	·00058	=	cubic feet.
„ „	×	·003617	=	Imperial gallon (nearly).
„ feet	×	6·252	=	„ „
Avoirdupois lbs.	×	·00893	=	cwts.
„ „	×	·00045	=	tons.

Scale of Measurements adopted for ascertaining Amount of Coal at Depôts, and Capacity of Stowage Room.

1 ton of Welsh coal	=	40	cubic feet.
1 ton of North Country coal	=	43	„ „

TO CALCULATE THE FLOATING POWER OF SPARS.

THE weight they will sustain is the difference between their own weight and that of the water they displace.

To ascertain the weight, multiply the square of the mean diameter in inches by ·7854 to find the area; multiply the area by the length to find the cubic contents; and the product by the weight of a cubic foot of the material.

EXAMPLE.

Topmast—length = 64 feet; mean diameter = 21 inches.

64 feet = 768 inches; and $\frac{21^2 \times \cdot 7854 \times 768}{1728} = 154$ cubic feet.

154 × 64·18 (the weight in lbs. of 1 cubic foot of salt water)	= 9883·7 lbs.
154 × 36·3 (the weight in lbs. of 1 cubic foot of Norway spars)	= 5590·2 lbs.
Floating power of spar	4293·5 lbs. = 38 cwt.

To find the content of square or four-sided timber, multiply the mean breadth by the mean thickness, and the product by the length.

To find the solid content of a tree, multiply the square of ⅓ of the mean girth by twice the length.

In making use of tanks, casks, etc., for floating purposes, the internal capacity is immediately obtained by multiplying the gallons it holds by ten, and subtracting the weight of the tank or cask. This gives the floating power in pounds.

In constructing a raft, it should be borne in mind that all the weight of human beings is to be placed *on* it, and that a great quantity of provisions and water may be safely carried *under* it.

For instance: a cask of beef slung beneath would be 116 lbs.; above, 300 lbs.

SPECIFIC GRAVITIES.

Barometer 30 in., Fahrenheit's thermometer 60°. Distilled water is represented by 1000.

Material.	Specific Gravity.	Weight of One Cubic Foot in lbs.
Ash	690 to 845	43·12 to 52·81
Beech	854 to 690	53·37 to 43·12
Birch	792	49·50
Box	960	60·00
Brass	8399	524·94
Cedar (fresh)	909	56·81
,, (seasoned)	753	47·06
Coal	1232 to 1657	77·0 to 103·56
Copper	8607	537·93
Elm (seasoned)	588	36·75
Fir (New England)	553	34·56
,, (Riga)	753	47·06
Gold	19258	1203·62
Iron	7700	481·25
Lead	11446	715·38
Lignum Vitæ	1220	76·25
Mahogany	800	50·00
Oak (English)	934	58·37
,, (African)	972	60·75
Pine	660	41·25
,,	461	28·81
Platinum	20150	1213·62
Silver	10312	644·50
Steel	7780	486·25
Teak	657	41·06
Tin	7291	455·69
Water (sea)	1027	64·18
,, (distilled)	1000	62·50
Walnut	671	41·94
Zinc	7028	439·25

To find the specific gravity of a substance: W = weight of body in X = weight in water. G = specific gravity. $G = \frac{W}{W-X}$.

If the substance be lighter than water, sink it by means of a he substance, and deduct additional weight.

Nat. Nos.	0	1	2	3	4	5	6	7	8	9	Proportional Parts. 1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	5	5	8	11	13	16	18	21	23
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3676	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5433	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6537	6646	6656	6665	6676	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6836	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6949	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7

Nat. Nos.	0	1	2	3	4	5	6	7	8	9	Proportional Parts. 1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7544	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	3	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8475	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8614	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9059	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	8340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9430	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	6513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	4	4

ANGLE.	Sine.	Diff. for 10′.	Arc.	Tangent.	Cotan.	Versine.	Cosine.	—
0°	·0000		·0000	·0000	infinite.	·0000	1·0000	90
1	·0175		·0175	·0175	57·290	·0002	·9998	89
2	·0349		·0349	·0349	28·636	·0006	·9994	88
3	·0523		·0524	·0524	19·081	·0014	·9986	87
4	·0698		·0698	·0700	14·301	·0024	·9976	86
5	·0872	·0029	·0873	·0875	11·430	·0038	·9962	85
6	·1045		·1047	·1051	9·514	·0055	·9945	84
7	·1219		·1222	·1228	8·144	·0075	·9925	83
8	·1392		·1396	·1405	7·115	·0097	·9903	82
9	·1564		·1571	·1584	6·314	·0123	·9877	81
10	·1736		·1745	·1763	5·671	·0152	·9848	80
11	·1908		·1920	·1944	5·145	·0184	·9816	79
12	·2079		·2094	·2126	4·705	·0219	·9781	78
13	·2250		·2269	·2309	4·331	·0256	·9744	77
14	·2419		·2443	·2493	4·011	·0297	·9703	76
15	·2588		·2618	·2679	3·732	·0341	·9659	75
16	·2756	·0028	·2793	·2867	3·487	·0387	·9613	74
17	·2924		·2967	·3057	3·271	·0437	·9503	73
18	·3090		·3142	·3249	3·078	·0489	·9511	72
19	·3256		·3316	·3443	2·904	·0545	·9455	71
20	·3420		·3491	·3640	2·747	·0603	·9397	70
21	·3584		·3665	·3839	2·605	·0664	·9336	69
22	·3746	·0027	·3840	·4040	2·475	·0728	·9272	68
23	·3907		·4014	·4245	2·356	·0795	·9205	67
24	·4067		·4189	·4452	2·246	·0865	·9135	66
25	·4226		·4363	·4663	2·145	·0937	·9063	65
26	·4384		·4538	·4877	2·050	·1012	·8988	64
27	·4540	·0026	·4712	·5095	1·963	·1090	·8910	63
28	·4995		·4887	·5317	1·881	·1171	·8829	62
29	·4848		·5061	·5543	1·804	·1254	·8746	61
30	·5000		·5236	·5774	1·732	·1340	·8660	60
31	·5150	·0025	·5411	·6009	1·664	·1428	·8572	59
32	·5290		·5585	·6249	1·600	·1520	·8480	58
33	·5446		·5760	·6494	1·540	·1613	·8387	57
34	·5592	·0024	·5934	·6745	1·483	·1710	·8290	56
35	·5736		·6109	·7002	1·428	·1808	·8192	55
36	·5878		·6283	·7265	1·376	·1910	·8000	54
37	·6018	·0023	·6458	·7536	1·327	·2014	·7986	53
38	·6157		·6632	·7813	1·280	·2120	·7880	52
39	·6293		·6807	·8098	1·235	·2229	·7771	51
40	·6428	·0022	·6981	·8391	1·192	·2340	·7660	50
41	·6561		·7156	·8693	1·150	·2453	·7547	49
42	·6691		·7330	·9004	1·111	·2509	·7431	48
43	·6820	·0021	·7505	·9325	1·073	·2686	·7314	47
44	·6947		·7679	·9657	1·036	·2807	·7193	46
45	·7071		·7854	1·0000	1·000	·2922	·7071	45
—	Cosine.	Diff. for 10′.	—	Cotan.	Tangent.	—	Sine.	Angle.

The Tonnage of Ships.

There are in common use the following tonnage measurements:—(1) displacement; (2) register tonnage; (3) builders' old measurement; (4) yacht measurement.

It is not to be wondered at that some confusion exists as to the exact meaning of the word "tonnage," seeing it is used in so many senses—sometimes expressing weight, at others capacity, and at others a purely arbitrary function of the principal dimensions.

Displacement Tonnage expresses the total weight of a ship (in tons) when immersed to her load-line. This measurement is specially suited for war ships, which are designed to carry certain maximum weights and to float at certain load-lines.

Register Tonnage is simply the internal capacity of the hold of the ship in cubic feet, with any additional spaces built on deck, divided by one hundred.

The tonnage of a merchant ship is usually stated both as "gross" and "nett." Gross tonnage expresses (in tons of 100 cubic feet) the total internal capacity of the ship, together with that of any closed-in spaces, such as deck-houses, etc., erected upon the deck for purposes of accommodation, or storage.

"Nett" tonnage expresses the cubical contents of the space actually available for remunerative service, the conveyance of passengers or stowage of cargo; it is sometimes called the "register tonnage."

The gross register tonnage of a ship may be found approximately by the following formula:—

L = the inside length on upper deck from plank at stem to plank at stern.
B = the inside main breadth from ceiling to ceiling.
D = the inside midship-depth from upper deck to ceiling at timber strake.

$$\text{Register tonnage} = \frac{L \times B \times D}{100} C.$$

Value of C

Sailing ships	Old full form	8
	Of the present usual form	7
Steam vessels and clippers	Ships of two decks	.65
	Ships of three decks	.68
Yachts	Above sixty tons	.50
	Under sixty tons	.45

Surveyor's Rule for Approximate Register Tonnage.

L = length in feet, B = breadth in feet, G = girth in feet.

R = approximate gross register tonnage.

$$R = \frac{17}{10{,}000}\left(\frac{G \times B}{2}\right)^2 L \text{ for wood and composite ships.}$$

$$R = \frac{18}{10{,}000}\left(\frac{G \times B}{2}\right)^2 L \text{ for iron vessels.}$$

Factors for Measurement and Dead-weight Cargoes.

1. To ascertain approximately for an average length of voyage the measurement cargo, at forty feet to the ton, which a ship can carry :—

Rule.—*Multiply the number of register tons by the factor* 1·875, *and the product will be the approximate measurement cargo.*

2. To ascertain approximately the dead-weight cargo in tons which a ship can carry on an average length of voyage :—

Rule.—*Multiply the number of register tons by* 1·5, *and the product will be the approximate dead-weight cargo.*

With regard to the cargoes of coasters and colliers, about 10 per cent. may be added to the said results ; while about 10 per cent. may be deducted in the cases of larger vessels going on long voyages.

In cases of measurement cargoes of steam vessels, the spaces occupied by the machinery, fuel, and passenger cabins below decks must be deducted from the space or tonnage under the deck before the application of the measurement factor thereto.

In the case of dead-weight cargoes, the weight of machinery, water in the boilers, and fuel, must be deducted from the whole dead-weight, as ascertained above.

The deductions necessary to be made for provisions, stores, etc., are allowed for in the selection of the two factors.

Measurement of Yachts for Tonnage.

Royal Thames Yacht Club.

Rule.—Measure the length of the yacht in a straight line on the deck, from the fore part of the stem to the after part of the stern-post, from which deduct the extreme breadth, which is measured from the outside of the outside planking; the remainder is the length for tonnage. Multiply the length for tonnage by the extreme breadth; that product by half the extreme breadth; and divide the results by 94; the quotient will be the tonnage.

If any part of the stem or stern-post project beyond the length as taken above, such projection or projections shall, for the purpose of finding the tonnage, be added to the length taken as before mentioned. All fractional parts of a ton shall be considered as a ton. The measurement to be taken either above or below the main wale.

If L = length, B = breadth, then

$$\text{Tonnage} = \frac{(L - B) \times B \times \frac{1}{2} B}{94}.$$

Corinthian and New Thames Yacht Clubs.

Rule.—Measure the length and breadth as in the foregoing rule, and the depth up to the top of the covering-board; multiply the length, breadth, and depth together, and divide the result by 200; the quotient will be the tonnage.

If L = length, B = breadth, D = depth, then

$$\text{Tonnage} = \frac{L \times B \times D}{200}.$$

Danube and Suez Canal Rules.

The so-called Danube rule for tonnage is based upon the English tonnage law of 1854, the allowance for coal and machinery being 50 per cent. above the measured space assigned to machinery in paddle steamers, and 75 per cent. in screw steamers.

The tariff of the Suez Canal is also based on the same law. The dues

charged upon the "nett tonnage." The spaces measured for gross tonnage are—space under the tonnage deck; space between tonnage deck and uppermost deck; all covered or closed-in spaces, such as poop, forecastle, officers' cabins, galleys, cook-houses, deck-houses, wheel-houses, and other enclosed or covered-in spaces employed for working the ship.

The deductions permitted are—berthing accommodation for the crew, not including spaces for stewards and passengers' servants; berthing accommodation for the officers, except the captain; galleys, cook-houses, etc., used exclusively for the crew; covered and closed-in spaces above the uppermost deck, employed for working the ship. In none of these spaces must cargo be carried or passengers berthed, and the total deduction under all these heads must not exceed five per cent. of the gross tonnage.

In steamers with *fixed* coal bunkers, the rule of the English code may be followed, or the owners may choose to have their vessels measured by the Danube rule. Vessels with *shifting* bunkers would be measured by the Danube rule. In no case, except in tugs, must the deduction for the propelling power exceed 50 per cent. of the gross tonnage; so that the maximum tonnage upon which a vessel can pay dues, in passing through the Canal, is 45 per cent. of her gross tonnage.

Tonnage of H.M. Ships as shown in the Navy List.

The tonnage marked against H.M. ships in the Navy List is the actual displacement of the ship, or the total weight of ship complete; the horse power being that which can be developed by the engines. The figures in parentheses ( ) show the tonnage, old measurement, and nominal horse power.

To find the Weight that will give a Ship One Inch Immersion (approximately).

Multiply length and breadth together and then divide by 525. Thus: with H.M.S. *Warrior* $\frac{380 \times 58}{525} = 42$ tons.

For yachts and small vessels the divisor should be 600.

Dimensions of some of H.M. Ships classed according to Length.

Ship's Name.	Indicated Horse Power.	No. of Guns.	Displacement. Tonnage.	Length.	Breadth.	Draught of Water.
			Tons.	Ft in.	Ft. in.	Ft. in.
NORTHUMBERLAND * ..	6560	27	10,780	400 4	59 5	27 9
WARRIOR *	5270	32	9210	380 2	58 4	26 9
ACHILLES *	5720	16	9820	380 0	58 3½	27 2
INCONSTANT	7360	16	5780	337 4	50 3½	24 6
ALEXANDRA *	8610	12	9490	325 0	63 8	26 6
INFLEXIBLE (*turret ship*)	8010	4	11,800	320 0	75 0	25 5
ROYAL YACHT (*wood ship*)	2980	—	2470	300 0	40 3	16 0
DEVASTATION (*turret ship*)	6650	4	9330	285 0	62 3	27 2
TÉMÉRAIRE *	7520	8	8540	285 0	62 0	27 0
AJAX (*turret ship*) ..	6440	4	8510	280 0	66 0	24 0
NELSON *	6640	12	7630	280 0	60 0	24 8
LORD WARDEN *	6700	18	7840	280 0	59 0½	27 11
HOTSPUR (*ram*)	3061	4	4010	235 0	50 0	20 8
FLIRT (*gun vessel*) ..	530	4	603	155 0	25 0	8 11

* Iron-cased broadside ships.

Note.—To lighten H.M.S. *Warrior* one inch it would be necessary to remove 42 tons of weight, or about 500 tons to lighten the ship *one foot*. The quickest way, probably, of doing *this* would be to take out the chain cables, say 128 tons, anchors 40 tons, water 90 tons, shot *113 tons*, powder 23 tons, leaving more than 100 tons to be made up by the removal of guns.

SECTION IX.

'ARTICULARS OF DOCKS ABROAD, WITH INFORMATION UPON COALS — FOREIGN SEA TERMS AND PHRASES — ROPE— CHAIN CABLES—ANCHORS—PAINTING SHIP—PRACTICAL RECIPES — INSTRUCTIONS FOR DIVERS — AND USEFUL INFORMATION FOR OFFICERS IN PASSING EXAMINATIONS FOR THE ROYAL NAVY OR MERCANTILE MARINE.

PARTICULARS OF DOCKS ABROAD.

French Dockyards and Mercantile Ports.

Dockyard.	Dock.	Length.	Breadth of Entrance.	Depth over Sill at High Water, ordinary Springs.	Rise of Tide.	
					Springs.	Neaps.
		Ft. in.	Ft. in.	Ft. in.	Feet.	Feet.
CHERBOURG ..	No. 1 Avant Port ..	246 0	60 0	27 0	17	12¾
	„ 2 South	490 0	80 0	27 0		
	„ 3 „	490 0	80 0	27 0		
	„ 4 West	270 0	60 0	27 0		
	„ 5 North	380 0	70 0	27 0		
	„ 6 „	380 0	70 0	27 0		
	„ 7 „	350 0	65 0	27 0		
	„ 8 „	350 0	65 0	27 0		
BREST	No. 1 Pontaniou	492 0	60 0	25 6	19	13¾
	„ 2 „	492 0	60 0	20 6		
	„ 3 and 4, double ..	720 0	90 0	33 0		
	„ 5 Brest	288 0	52 0	25 6		
L'ORIENT ..	No. 1	350 0	..	..	13	9½
	„ 2	500 0				
ROCHELLE ..	Dock	..	55 0	20 to 21		
ROCHEFORT ..	Double dock	584 0	30 0	..	17	13
	North	350 0	60 0	..	16¾	13½
DUNKERQUE ..	Dry Docks 1 and 2 ..	360 0 constructing				
	Basin de la Marine ..	990 0	330 0	20½		
	Basin de l'Arrière Port ..	990 0	270 0	20½		
	Basin de Freycinet (Patent Slip)	1716 0				

HAVRE Floating Basins. The Port of Le Havre, besides the tidal harbour, consists of ten floating basins or docks, which communicate with each other by gates. The basins are capable of receiving large merchant vessels. Steam vessels of heavy tonnage go into the Floride and the Eure basins. The locks opening from the harbour into the Floride and Saint Jean basins are 68 feet 10 inches wide, and those leading direct from the harbour into the Eure basin are 100 feet wide. The depth of water on the sill of the Eure dock is 25 feet at springs. The other locks are from 52½ feet to 37½ feet wide, which last is the lock leading into the Vauban Basin, where British colliers lie.

At Havre the high water remains stationary for one hour, with a rise and fall of three or four inches for anotner hour, and only rises and falls thirteen inches for the space of three hours; this long period of nearly slack water is very valuable to the traffic of the port, and allows from fifteen to sixteen vessels to enter or leave the docks on the same tide.

BREST.—The French Government contemplates extending the Dockyard, and making one or two large Dry Docks.

L'ORIENT.—The factories for steel ship building are now complete. They are situated in one long building, each wing of which contains sufficient plant for constructing a first-class ironclad.—Ships are built here with greater economy and rapidity than at any other port in France.

SABLES D'OLONE.—Dock capable of admitting vessels of 16 feet draught at high water springs.

ROCHEFORT.—There is a commodious Dock; with steam cranes for discharging vessels.

DUNKERQUE.—The Patent Slip is capable of taking vessels of 1000 tons.

Sweden, Germany, Holland, Belgium.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
OSCARSHAMN ..	Stone Dock ..	300 about	..	..	..	..	..
SWINEMUNDE ..	Iron Floating Dock	..	..	..	..	..	1867
JAHDE BAY ..	Dry Docks, No. 1	375	60	16 to 17	..	..	..
	,, ,, 2	250	50	12			
	Six Patent Slips						
KIEL FIORD ..	No. 1 (southern)	360	77	27·6	..	..	1876
	,, 2 ,, ..	329	72	25·7			
	,, 3 ,, ..	309	72	22·7			
	,, 4 (northern)	309	72	19·4			
	Three Graving Docks						
	Iron Floating Dock						
STAVANGAR ..	Dry Dock, No. 1	290	52	10 to 12	..	..	..
	,, ,, 2	200	52	12 to 14			
HAMBURG ..	Floating Dock, No. 1	290	45	13 (submerged to)	12	..	..
	,, ,, No. 2	210	45	,,			
WILLIAMSHAVEN	Dry Docks, No. 1	440	84	29	13	..	..
	,, ,, 2	440	84	29			
	,, ,, 3	380					
BREMERHAVEN	Dry Docks, No. 1	200	42	13	12	..	.
	,, ,, 2	360	56	16			
	,, ,, 3	300	54	16			
	,, ,, 4	370	56	17			
	,, ,, 5	400	60	24			
WILLEMSOORD ..	Dry Docks, No. 1	361 on blocks	..	..	4½	3¾	
	,, ,, 2	264					

CARLSCRONA.—The Swedish Government Docks are at Carlscrona.

SWINEMUNDE.—The Floating Dock is for the reception of vessels of 20 feet draught, with the exception of iron-plated frigates.

JAHDE BAY.—There are two harbours in this bay, the outer and inner, in which extensive works are in progress.

KIEL.—The Construction Basin (on the southern shore of the harbour, near the village of Ellerbek) covers a square area; the length of a side measures 700 feet, and the constant depth of water is 30 feet. The Equipment Basin, close by, is 700 feet wide and 930 feet long, the depth being 34 feet at ordinary sea-level. The canal connecting the two basins has a clear width of 77 feet and a length of 206 feet. The entrance into the basin from the harbour is 295 feet wide and 606 feet long; the depth is about 34 feet. West of the construction basin are situated the four great Dry Docks.

DANTZIG—Floating Dock, 300 feet in length (iron), is of 7000 tons capacity. Patent Slip, 330 feet in length.

MALMO (SWEDEN).—There is a Patent Slip, 800 feet in length, and capable of taking in vessels up to 1700 tons.

HAMBURG.—Two Patent Slips can take up vessels of 1200 tons register, two can take vessels of 500 tons register, and the remaining two are for small vessels.

ALTONA.—Floating and Dry Docks.

WILLIAMSHAVEN.—No. 3 Dock admits the smaller ironclad ships, and corvettes. There are two Building Slips for building ships of war of the largest size. These works belong to the German Government.

BREMERHAVEN.—Docks Nos. 1, 3, 4, and 5 will admit two vessels at a time.

Holland, Belgium, Spain.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
GEESTEMUNDE ..	Dry Docks, No. 1	340	42	14	..	..	..
	„ „ 2	230	40	13			
ROTTERDAM ..	Floating Dock (Charbois)	286	53	12	7	..	..
	Do. Hihhervur	..	158	10½			
	Four Patent Slips						
FLUSHING ..	3 Floating Docks	..	65 each	25 each	15	11	..
	No. 1 Dock ..	243	52	14			
	Patent Slip						
MIDDLEBURGH ..	Graving Dock ..	420	66	16	..	..	..
ANTWERP ..	Dry Docks, No. 1	360·9	81·3	20⅔	15	..	..
	„ „ 2	196·8	39·4	11⅔			
	„ „ 3	134·3	32·8	7⅓			
	Gridiron	..	..	9			
	Floating Docks, Old	..	54	22			
	New	..	82	24			
FERROL	Dry Dock ..	474	78	31	..	..	1879
CADIZ	No. 1	344	..	24½	9½	..	..
	Lopez Dock ..	500	62	26½	..	..	1878

Mediterranean.

CARTAGENA ..	Iron Floating ..	325	105	..	..	..	..
ALGIERS ..	No. 1	426	100 to 110	32	..	..	..
	„ 2	278	65¼	25½			
MARSEILLE ..	No. 1	433	83½	23	..	..	..
	„ 2	346	83½	19½			
	„ 3	280	62½	19½			
	„ 4	280	62½	19½			

AMSTERDAM.—The Floating (Wet) Docks have an area of above 4000 yards, are about 50 feet wide, and admit vessels drawing 15 feet. At Dockyard, two covered slips for building large corvettes, and four slips for small vessels. No Graving Docks.

ROTTERDAM.—A Patent Slip at Delfshaven for ships of 2000 tons; at Feymwood for ships of 1500 tons; at Schiedam for ships of 2000 tons; and at Papendrecht for ships of 1600 tons.

HELLEVOETSLIUS.—One large Dry Dock, divided into two, built in the year 1800, of brick, is in bad repair, but suitable for monitors and other vessels of the navy.

FLUSHING.—In two of the docks ships drawing 25 feet can enter.

CADIZ.—The Government Docks are adjoining the Arsenal at Carraca; they are three in number, 200, 250, and 350 feet in length. The passage to the docks is narrow, with 2¾ fathoms least water, and a pilot should be employed. There are also two Slips, one will take 137 feet length of keel; mean draught of water 9 feet in Trocadero Channel.

CARTAGENA.—Will lift 6500 tons independent of weight of dock, and can receive a vessel of 27 feet draught.

BARCELONA.—Gridiron Slip adapted for vessels of moderate tonnage.

ALGIERS.—The Docks, which are near each other, about half a mile south of the town, belong to the French Government. Repairs of almost every description can be executed with facility. The largest ships may be repaired, the only expense being that of keeping the docks dry.

MARSEILLE.—Docks situated round a repairing basin within the National basin; sites marked out for two additional dry docks. Repairing basin large enough for steamships of 3000 or 4000 tons to swing in. Contemplated to erect a ship hydraulic lift. Four centrifugal pumps fitted for general service of docks; will pump No. 1 dry in 3 hours, No. 2 in 2½ hours, Nos. 3 and 4 in 1½ hours.

Mediterranean.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
TOULON	No. 1 Arsenal ..	249	75½	20	..	..	..
	,, 2 ,, ..	245	77	21½			
	,, 3 ,, ..	292	78½	26			
	,, 4 Castigneau	325	89½	26			
	,, 5 ,, ..	387	92	26			
	,, 6 ,, ..	239	92	26½			
	Double	535					
	Missiessy Dock No. 1 ..	380	82	34½			
GENOA	One	285	75	19½	..	..	..
	Landing Slip ..	620	60	23			
SPEZIA	No. 1	328	85	27½	..	..	..
	,, 2	393	82	26			
	,, 3	393	82	26			
	,, 4	328					
LEGHORN ..	One	352	69	23	..	..	..
	Patent Slip ..	275					
NAPLES	One	239	63	22	..	..	..
MESSINA ..	Dry Dock ..	359	82(width at top)	26	..	..	..
POLA	Balance Dock ..	468	83	28	3½	..	..
	Dry Dock (Olive Island) ..	452	80	27	..	..	1868
VENICE	No. 1, Graving Dock	410	72	31	..	..	1878
	No. 2, Do. ..	295	59	20			
	Two Building Slips						
TRIESTE	Graving Dock ..	437	74	23¾	3	..	..
MALTA .. .. (Dockyard)	Outer	256 1 in.	81 4½ in.	25	..	..	..
	Inner	300	73 2 in.	25			
	Somerset ..	468 (428 blocks)	80	33½			

TOULON.—At Missiessy there is a Graving Dock of same dimensions as Missiessy Dock No. 1.

ITALIAN PORTS.—There are Dockyards at Spezia, Genoa, Leghorn, Venice, and Naples. There are Arsenals and Naval Depôts at Spezia, Genoa, Venice, Ancona, Naples, Taranto, Messina, Gaeta, and Porto Ferrajo.

There are also the following fortified Naval Harbours: Chioggia, Brindisi, Syracuse, Messina, Palermo, Isola Porza, Baja, Pizza, Porto Ferrajo, Gaeta, Civita Vecchia, Longone, Monte Argentaro, and Orbetello. (There are 303 places of landing.)

There are coaling stations at Genoa, Spezia, Varignano, Civita Vecchia, Cagliari, Porto Ferrajo, Naples, Castellamare, Gaeta, Taranto, Palermo, Messina, Venice, Ancona, Brindisi, and Peschiera.

GENOA.—The Dock within the Royal Arsenal and at the head of the harbour. The Landing Slip, the part of which out of water is 200 feet, is capable of receiving a vessel of 1000 to 1200 tons.

LEGHORN.—Patent Slip, adapted to vessels of 1500 tons weight.

NAPLES.—There is a temporary Slip for merchant vessels.

CASTELLAMARE.—There are three Slips for building frigates.

MESSINA.—Dry Dock adapted for repairs of every class of vessel.

PALERMO.—A Patent Slip.

ANCONA.—Basin building.

POLA.—The new Dock to be completed at Pola will be the largest in Italy. The other dry Dock on Olive Island is out of repair, and weak.

VENICE.—There are two Building Slips, with good foundations, and granite superstructure on which modern war ships (iron and steel) are built.

TRIESTE.—The Graving Dock is in the naval arsenal belonging to Lloyd's Steam Navigation Company. There are five sills, each 30 feet apart, so that the dock can be shortened by 150 feet, viz. to suit the lengths of vessels of the following dimensions, 302, 332, 362, 392, and 422 feet. Morton's Patent Slip, with the Dry Dock, can take two vessels 1100 tons each.

Mediterranean.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
MALTA (Quarantine Harbour)	Lift Dock .. (*See* Remarks)	346 pontoon	60½	18½	..	..	1875
ALEXANDRIA ..	Government ..	235	58½	19	..	..	..
CONSTANTINOPLE	Two, Nos. 1 and 2	220	60	25	..	..	..
	One, No. 3 ..	400	70				
SEVASTOPOL ..	Depositing Dock (sectional) ..	280	72 or 144	20 or 22 over blocks	..	..	..
NICOLAIEFF ..	Depositing Dock	280	72 or 144	20 or 22 over blocks	..	..	..

Cape of Good Hope, Indian Ocean, Red Sea.

CAPE OF GOOD HOPE							
„ (Simon's Bay)	Patent Slip	..	..	..	..	..	1882
„ (Table Bay)	Outer Basin ..	850	200	..	5		
	Inner Basin ..	1025	450–250				
	Dry Dock ..	530 / 500*	68	26	5	3	
	Patent Slip						
MAURITIUS ..	Hay Dock ..	318	47½	17			
	Stevenson Dock	378	60	20	3	2½	..
	Albion Dock ..	318	60	20			
RÉUNION ..	Wet Dock ..	..	..	..	..	..	..
SUEZ	One. S.E. of town, 2 miles (at head of South Basin).	410	80	26	6	4	..

* Denotes the extreme length on blocks.

MALTA.—*Lift Dock.*—Length of pontoon, 346 feet; width, 60½ feet; depth, 8 feet; draft, with pontoon lowered, 18½ feet. This dock can lift, and the pontoon can float, a vessel of 3000 tons dead weight. It is connected to the shore on the south side of the Messida creek by a bridge. There is no arrangement at present for fitting cradle blocks to the girders, so that the pontoon must be in when a ship is lifted, consequently a vessel of more than 18·6 or 18·9 draught cannot enter. A second pontoon, 210 feet by 56 feet, by 6 feet, will carry 1200 tons dead weight. Width between columns of lift, 62½ feet clear.

ALEXANDRIA.—There are several Building Slips.

ODESSA.—There are three Wet Docks, closed with quays.

SEVASTOPOL.—The Sectional Dock at Sevastopol can take a vessel 400 feet long, and is stated to be equal to a weight of 6000 tons. Imperial yacht *Livadia* docked August, 1881.

NICOLAIEFF.—The Depositing Dock can take vessels of 400 feet, or 200 feet.

SIMON'S BAY.—A vessel of 11 feet draught forward, 14 feet aft, and 1000 tons displacement is the outside that can be taken up on the patent slip, and only at spring tides.

COALS.—Welsh, and North Country, also Patent Fuel from Naval Yard. May be purchased from Anderson and Co. Sent alongside in iron lighters at about the rate of 250 tons a day if fine. If purchased, it is sent off in wooden sailing boats holding about 8 tons.

TABLE BAY.—OUTER BASIN.—The depth at low water springs close up to the east jetty is 18 feet, gradually decreasing to 7 or 8 at a distance of 50 feet off the western side of the dock; at the entrance there is a depth of nearly 21 feet.

INNER BASIN.—There is a uniform depth of nearly 21 feet at low water springs in the passage from the entrance to the outer basin to the entrance of the inner, and inside the basin 24 feet over the whole of the northern part, decreasing to 19 and 20 in the southern portion. The basins are connected by rail with Cape Town.

PATENT SLIP.—The Patent Slip at the south end of the inner basin is capable of taking a vessel of 1500 tons.

A new Dock is being built, cut out of solid rock; it has 21 feet depth, and is 60 feet wide.

COALS.—Welsh, Messrs. Anderson and Co. contractors; sent alongside in lighters and hulks, could put off about 600 tons in 24 hours. Steamers not drawing more than 20 feet can coal in the docks.

MAURITIUS.—The Docks are about on a par with those of Bombay; it would not be safe to dock any vessel with a draught over 19 feet 6 inches. "Dry Dock Company," small defects to machinery can be made good. All large castings are done under contract with the "Foreign and Foundries Company." This establishment is quite capable of turning out pistons and shafting, and in fact making good defects generally; it is situated over a mile from the Custom House.

COALS.—Welsh, 41*s.* 11*d.*, and North Country, 40*s.* 11*d.* per ton, by contract. Sent off in 50 ton lighters. Can get about 300 tons in a day; about 1500 tons in store.

RÉUNION.—Wet Dock constructing on lee side of island, at Port des Galets (St. Paul); about 20 acres of surface water, with 26 feet depth. Some 40 vessels will be berthed.

SUEZ.—Conveniences for entering Dock—30 feet in channel leading to entrance of basin; 24 feet in basin outside dock gates. Maximum draught recommended 23 feet, on account of mud deposit at head of basin outside dock gates. Cost for first day £70, and £35 for each succeeding day. Dock Company take no responsibility. Nothing in the way of stores, merely the dock. No workshops near dock, but at an old P. and O. factory beyond the town of Suez ordinary repairs to hull and machinery can be effected. Dock fitted with rudder well, for convenience in shipping and unshipping rudders.

India.

Name of Port.		Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
						Springs.	Neaps.	
			Feet.	Feet.	Feet.	Feet.	Feet.	
Bombay ..	Government.	Lower Bombay	256	52	16½	12 to 17	..	..
		Middle	186	52	16½			
		Upper Bombay	202	48	14			
		Lower Duncan ..	259	63½	18			
		Upper „ ..	306	63½	18½			
	Mercantile.	P. & O. Old Dock .. (Mazagon)	177	44	16 to 18			
		P. & O. Ritchie Dock	469	67	18 to 21	*See* Special Tide Tables for Indian Ports, published by authority of Secretary of State for India; also page 210.		
		B. I. Mogul Dock (Lower)	217	60	17			
		B. I. Mogul Dock (Upper)	196	47	17			
		Sassoon Basin ..	632	40	21½ to 23½			
		Hydraulic Lift (Hog Island)	380	88	29			
		Princess Dock (Wet)	..	..	28	..	..	1880
		Viegas Patent Slip Cradle	232					
Calcutta ..		Calcutta Dock (Calcutta Dock Co., Limited), (Dry Dock)	370 / 354*	51	23½ † / 19½ ‡	12 to 15	..	..
		Caledonia Dock (Babio Jaruknath Paramathnick)	226 / 215*	44½	24½ † / 20 ‡			
		Commercial Dock (Calcutta Co., Limited)	225 / 212*	41½	18 † / 14½ ‡			
		Hooghly Dock (Messrs. Reid and Co.)	290 / 260*	45	? 24½ † / 16½ ‡	*See* Special Tide Tables for Indian Ports, published by authority of Secretary of State for India; also page 210.		
	B. S. S. N. Co.	Howrack Dock (Upper)	326½ / 305*	52	25½ † / 20½ ‡			
	B. S. S. N. Co.	Howrack Dock (Lower)	209 / 190*	40½	19½ † / 14½ ‡			
	B. S. S. N. Co.	Union Dock (Upper)	353 / 342½*	76	21½ † / 16½ ‡			
	B. S. S. N. Co.	Union Dock (Lower)	368 / 354½*	57	22½ † / 18½ ‡			

* Denotes the extreme length on blocks.
† Denotes the average depth at H. W. Springs from June to October at Calcutta.
‡ Denotes the average depth at H. W. Springs from October to June at Calcutta.

BOMBAY.—The Government Docks are on the west side of the harbour, near the Custom House. The Lower, Middle, and Upper Docks can be used as one dock. The two Duncan Docks, also the two Mogul Docks, can be used as one dock, 532 feet in length. A gridiron is adjacent for small vessels. The Mercantile Docks belonging to the British India S. N. Co. and to the P. and O. S. N. Co. are about 2½ miles north of Bombay Fort; the P. and O. being just north, and the B. S. just south of Mazagon pier.

Sassoon Basin is situated one mile north of Observatory. Ritchie Dock (P. and O.) was re-opened in 1880, having been lengthened about 50 feet, but otherwise unaltered.

The British India Company's Graving Dock is capable of taking a vessel 550 feet length, 40 feet beam, drawing 14 feet.

Hydraulic Lift, at Hog Island, only suitable for flat-bottom vessels, such as H.M. Indian troop ships; authorities declined to take *Glasgow* or even *Columbine*.

Princess Dock (Wet), opened 1st January, 1880, has an area of 30 acres of water; it is 1460 feet long by 240 wide. There are two entrances, respectively 66 feet and 55 feet in width; the depth on the sills of both is 28 feet at high water ordinary spring tides. The draught for entering is limited to 20 feet.

COALS.—Welsh, and North Country, by contract. Sent off in 50 ton dhows. Get about 300 tons a day. From ship's moorings to the coal wharf is about 4 miles, which causes a little delay.

CALCUTTA.—The Calcutta Dock can be lengthened 300 feet, the Caledonian 200, and the Commercial 40.

COALS.—From Indian Government Depôt. Sent off in 20 ton lighters. Get about 200 tons a day.

East Indies.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Length over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
					Springs.	Neaps.	
CALCUTTA		Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Indian Government.	Kidderpore (Upper Dock)	211 180*	77½	16½ † 12½ ‡			
	Kidderpore (Middle Dock)	226½ 192*	77½	20½ † 16½ ‡			
	Kidderpore (Lower Dock)	207 174*	83½	18½ † 14½ ‡			
MAULMAIN ..	.. .. ..	250	42	13 at highest springs	8	..	..
RANGOON ..	Dalla Dock ..	Uncertn.	52	13	21	14	..
	Gridiron	210					
	Floating Dry Dock	300	50				
PENANG	Dry Dock ..	250 (on blocks)	50	14 to 15	9	7½	1881
BANGKOK ..	One	300	100	15	7½ to 11	8½	..
SINGAPORE ..	Chermin Bay, No. 1	459	62	19 to 20	..	..	..
	Chermin Bay, No. 2	415	42	14 to 15½	10	7½	
	Tanjong Pagar (Victoria), No. 3	450	65	20			
	Albert Dock ..	468	60	21 at mean water	..	..	1879
	South Side, Pulo Brani (Bon Accord) No. 4	200	(closed)				
ONRUST	Wood Floating Dock, *Onrust*	360	62	20	2	..	..
BATAVIA ..	Floating Dry Dock, *Amsterdam*	304	40	17	..	..	..
SOURABAYA ..	Iron Floating Dock, *Sourabaya*	295	25	20	4 to 6	..	..
	Two Building Slips		..	..	..	..	1879
	Wood Floating Dock	..					

* Denotes the extreme length on blocks.
† Denotes the average depth at H. W. Springs from June to October at Calcutta.
‡ Denotes the average depth at H. W. Springs from October to June at Calcutta.

MAULMAIN.—The greatest draught recommended 12 feet, and that probably too heavy in N.E. Monsoon.

Coals can be purchased.

RANGOON.—In the Floating Dry Dock vessels to 15 feet draught can be taken in at any time of tide.

COALS.—Welsh, by contract. Sent off in 20 ton dhows that drop down with the tide. Get about 300 tons a day.

PENANG.—Patent Slip suitable for vessels 120 feet long, but not exceeding 200 tons burden.

Coals can be purchased.

BANGKOK.—The Dock is capable of taking a vessel of 800 tons. Its entrance is 120 feet from the river, with a spacious jetty, alongside of which vessels of any size may be taken at any state of the tides; there are also several mud docks.

Coals can be purchased.

SINGAPORE.—Tanjong Pagar Dock (Victoria) is entirely exposed, and any shipping in it might be easily destroyed from the eastward, while Chermin Bay Docks are defended by Hantu Island and the battery on Mount Faber. This dock finished, with extensive wharf accommodation attached, and deep water alongside the wharves. The large steamers of the P. and O. Co., and all the large ships and steamers calling at the port, use these wharves. H.M.S. *Charybdis* docked in Victoria Dock; greatest depth on sill 18½ feet.

Pulo Brani (Bon Accord Dock).—Reported closed.

COALS.—Welsh and Australian coal by contract for men-of-war, £1 14*s.* per ton. Ship coals alongside wharf; can get about 300 tons in a day. Coal is taken in at New Harbour. Large quantities are stored. Every facility for coaling.

ONRUST is about nine miles west of Batavia; the Dutch war ship *Koning der Nederlanden*, 5500 tons, was docked in the Floating Dock.

BATAVIA.—The *Amsterdam* Floating Dry Dock is capable of taking vessels of 4000 tons, and of docking the *Sourabaya* Dock.

Coals can be purchased.

SOURABAYA.—The Wood Floating Dock can only take vessels 170 feet long. There are the usual appliances at Sourabaya for repairs of every description.

Coals can always be obtained.

SAIGON.—The French Government contemplate constructing a Graving Dock at a cost of £320,000.

Coals can be obtained.

China and Japan.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.*		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
Fu-chau ..	Fu-chau Dock ..	400	55	15 to 17	17	14½	1865
	Patent Slip ..	304	..	..	..	..	1868
Hong-Kong ..	Kowloon, No. 1..	340	74	18	7 to 8	2½	1866
	Kowloon, No. 2..	245	49	14			
	Kowloon, No. 3†	450	85	28	..	..	1867
	Hope Dock(Aberdeen Bay)	433	84	24½‡	4½		
	Lamont's Aberdeen Dock	340	64	16	..	..	1869
	Cosmopolitan Dock	460	85	21	8 ft. 9 in. reported	5	1875
	Slip at East Point Belcher Bay	250		6 to 10	..	..	1874
Canton	Coupons ..	500	85	14	6	4	1858
	Looksun ..	450	75	17½	6	4	1867
Whampoa ..	Cooper's Dock ..	500	85	14	7 to 8	3 to 5	1868
	Hood Tsoon ..	350	59	18			
Amoy	Amoy Dock ..	310	60	16	18	14	1850
	Kulangsen ..	245	66	13	..	..	1865
	Bellamy Dock ..	185	51	12	..	..	1863
Ningpo	Small Mud Dock	160	33	7½ to 9	9		
Shanghai ..	Old Dock (Farnham & Co.)	400	57	17	10	7	1853
	Tunkadoo ..	350	70	16	..	..	1862
	Boyd's	450	80	18			
	C. M. S. N. Co. ..	345	70	10	..	..	1862
	Old Dock, Boyd's	245	60	12	..	..	1867
	Kianquan Provincial Government	280	79	17	..	..	1870
Pei-ho River ..	Taku Dry Dock	390	40	13	10	7 to 8	
Yokohama (Yokoska)	South Dock ..	502	94	27¾			
	North Dock ..	407	72	23	8	4	
Nagasaki ..	Graving Dock ..	420	89	27	9	7½	1879
	Patent Slip						

* The tides on the coast of China are affected by a large diurnal inequality. See page 211.
† No. 3 Dock is to be built adjoining No. 2 Dock in Hongham Bay.
‡ The sill and floor are level. This depth is seldom attained on sill.

FU-CHAU.—The Dock can take a vessel of 300 feet length of keel. Depth, 22 feet; width at top, 80 feet; and at bottom, 40 feet. A tug can be obtained.

There is a Patent Slip at the Chinese Arsenal, below Fu-chau, on which vessels are raised sideways. The cradle is in two parts, and may be used separately or together; separately, will take up two small vessels; together, will lift vessels of 2000 tons.

COALS.—British and Kelung coal can be purchased at Pagoda Island.

HONG-KONG.—The Slip at East Point is adapted for vessels of 300 tons; the Slip at Belcher Bay adapted to vessels of 1200 tons.

At Hong-Kong, as at all ports in China Sea, during N.E. Monsoon the high tides occur at night, and during S.W. Monsoon high tides are by day.

COALS.—Government depôt. Welsh, patent fuel, and Takasima, sent off in lighters. Get about 200 tons in 24 hours; 2000 to 3000 usually in store. Private firms keep large quantities stored.

CANTON.—Coals can be purchased.

WHAMPOA.—There are five mud docks on Danes Island, and four on Whampoa Island, but all in dilapidated state. In March the day and night tides rise to the same level. From April to October the day tides are the higher, and from November to February the lower. In May and June the level of spring tides is 4 feet, and the neaps 2 feet higher than in March.

AMOY.—The Amoy Dock has 18½ feet on the blocks from August to December. In April the tide may not allow more than 16 feet.

Coal supplied from Hong Kong and stored. It is put on board by local contractors.

SHANGHAI.—Both the old and new docks are fitted with steam pumps.

COALS.—Welsh and Takasima coal. Contract about $12 per ton, sent alongside in lighters and put on board by coolies. Get about 300 tons in a day.

YANG TSE KIANG R.—At Hong Meaon Arsenal, near Nankin, there is a wooden dock 320 feet long, with 18 or 19 feet at high water.

VLADIVOSTOCK.—Dock works were in 1884 being rapidly proceeded with; and a hydraulic lift (which can be used as one or three docks), capable of lifting vessels of 4500 tons, is in course of construction.

PEIHO R. TAKU.—Dry Dock, completed for gun-boats September, 1880. Steam pump and machine shop. Doubtful if available for merchant vessels.

KOBE.—Patent Slip, length 300 feet, suitable for vessels of 800 tons. Also Slip building for vessels up to 1000 tons. Both slips exposed during S.W. Monsoon. Risk would be incurred if on slip during a typhoon. Ironworks suitable for general repairs. Small steamers are built and engined.

YOKOHAMA (YOKOSKA).—Yokoska is intended to be an arsenal for repair and equipment of ships of the Japanese Government. Dock open to foreign merchant vessels and men-of-war. Two building capable of building a sloop of *Egeria* class, 940 tons, 1010 horse-power. South Dock will dock 328 feet; North Dock, 269 feet. Yokoska Dock is more convenient for docking a large ship than Aberdeen Dock, Hong Kong. A new dock is being excavated of considerable length, to take vessels of 24 feet draught.

COALS.—Welsh, Takasima, and patent fuel. Government depôt; from 2000 to 3000 tons usually in store. Sent off in lighters; can get about 200 tons in a day.

NAGASAKI.—The Patent Slip is now available for docking ships of 1200 tons; substantially built, in a secure position. Charge for three days' use, one dollar per ton. Dock situated on West shore. The authorities will not at present take in more than 24 feet.

Arsenal one mile above Dock, on West shore. No building slips, but resources of arsenal sufficient for iron ship building.

COALS.—Welsh, patent fuel, and Takasima, from Government depôts. From 2000 to 3000 tons usually kept. Sent off in lighters. About 200 tons can be shipped in a day.

Australia, New Zealand, and Tasmania.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.*		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
PORT ADELAIDE	Three Patent Slips	..	..	..	8	5 to 5½	..
MELBOURNE .. (HOBSON BAY)	Oswald and Inglis Floating Dock	152	30	13·3	3	2 to 2½	..
	Duke's Small Slip	300	30	9			
(WILLIAMSTOWN)	Alfred Graving Dock†	470	80	25 low tide, 27 28 occasionally	..	..	1874
	Government (Patent Slip)	720	75	..	..	..	1858
	Wright's Patent Slip	600					
SYDNEY ..	Fitz Roy Dock, Cockatoo Island	363	83	21 to 21½	4½	4	..
	Morts, Waterview Bay	410	75	19½			
BRISBANE ..	Dry Dock ..	300	60	20	6½	5	..
NEW ZEALAND..	Port Nicholson, Graving Dock	370	50	19 to 21	5	2½	..
	Otago (Port Chalmers) ..	330	68	20	5 to 7		
	Lyttleton ..	450 on floor	62	23	7½	5½	
	Auckland (Graving Dock) ..	310	44	13·6	..	..	..
	Do. Calliope Point	500	90	30			
HOBARTOWN ..	Floating Dock .. Wet D	250	30	12	4½	3½	..

* The Australian tides are affected by a large diurnal inequality. *See* pages 211, 212.

† H.M.S. *Bacchante* docked in Alfred Dock, June, 1881. The depth on sill, with a continuance of northerly and easterly winds, was scarcely more than 23 feet low water springs.

PORT ADELAIDE.—The largest Patent Slip, *Dunnikier*, is available for vessels of 1800 tons; another, vessels of 500 tons, and vessels of 200 tons can be repaired on the smallest slip.

Wet Dock opened September, 1880, covers nine acres, 2000 feet wharfage, 20 feet water near to wharves at low water. The entrance is 80 feet wide, and 20 feet deep at low water. It is proposed to make a Wet Dock having an area of 26 acres.

COALS.—Australian coal is brought by steamer direct from the Newcastle and Wollongong mines to Adelaide. It costs about 38*s.* per ton, and is sent off in lighters towed by tugs. About 300 tons are put alongside in a day.

HOBSON BAY.—Oswald and Inglis Dock will take in vessels of 700 tons register, and not over 12 feet draught. Duke's Small Slip is adapted for vessels of 50 tons, drawing 9 feet.

COALS.—Australian coal is brought by steamer from the Newcastle and Wollongong mines, price from 20*s.* to 30*s.* per ton. Sent alongside in lighters towed by tugs. Can get about 750 tons in a day.

WILLIAMSTOWN.—The Government Patent Slip is guaranteed to take up a ship of 2000 tons weight. Length of cradle, 203 feet. Length of ways below low water mark, 460 feet; length of ways above low water mark, 318 feet. Carries 25 feet of water.

On Wright's Patent Slip, vessels of 500 tons register can be hauled up.

The Alfred Dock is 450 feet long on floor; available length to side of caisson, 459 feet.

There is a complete set of factories and workshops. It is close to the Railway Pier and the entrance of the River Yarra.

SYDNEY.—Pyrmont Patent Slip, at Darling Point, is 850 feet. A vessel of 2000 tons can be hauled up in about 5 hours. Towns Patent Slip, Darling Harbour, is 400 feet long.

Floating Dock is capable of receiving vessels of 250 tons.

Morts Dock has a complete set of factories and workshops.

COALS.—Australian coals, Bulli, Newcastle, Cael-cliff, Warabah, 12*s.* to 14*s.* per ton, by steamer from coal mines. Steamers go alongside to discharge, and could put 800 tons on board in a day.

BRISBANE.—Patent Slip for small craft. Small repairs to machinery could be made good.

COALS.—Australian coal, Newcastle, and Ipswich, can be purchased; average price 13*s.* a ton in the river, 20*s.* in the bay. Sent off in lighters and steamers; can get from 300 to 400 tons in a day.

NEW ZEALAND.—PORT NICHOLSON.—The Slip in the south part of Evans Bay is capable of taking a ship of 2000 tons. There is a depth of 31 feet at high water at end of slip. Others for small vessels. Small repairs to machinery and boilers could be made good in private yards.

COALS.—Australian and New Zealand coal can be purchased from 25*s.* to 30*s.* per ton. The hulks are towed alongside, and about 500 tons can be put on board in a day.

PORT CHALMERS.—Floating Dock about 150 feet long, suitable for vessels of 400 tons.

COALS.—Australian and New Zealand coal can be purchased, 24*s.* per ton. Towed alongside in hulks; get about 400 tons in a day.

Lyttleton Graving Dock can be lengthened 100 feet.

COALS.—Australian and New Zealand coal can be purchased at Auckland at about 23*s.* per ton, brought alongside in barges towed by tugs. Can get about 750 tons in a day.

HOBARTOWN.—A vessel of 800 to 1200 tons can be hauled up on No. 1 Slip. One of 190 feet keel has been on it. Over the cradle there are 11 feet water at the inner and 24 feet at the outer end. No. 2 Slip is adapted for a vessel of 500 tons. No. 3 Slip will take a vessel of 300 tons. There are 8½ feet water over the cradle when it is let down. No. 4 Slip is capable of taking up a vessel of 300 tons.

The Wet Dock is adapted for vessels of 12 feet draught.

COALS.—Australian coal can be purchased from 26*s.* to 36*s.* per ton. Sent alongside in barges towed by tugs at the rate of 400 tons per day.

Brazils and Pacific.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
RIO JANERIO ..	Cobras I., No. 1	423	70	24	4	3	..
	No. 2 (Imperial)	258	55	20			
	Coal Island (Commercial)	405	45	18			
	Pinnie, Kemp & Co.'s Dock ..	400	70	24			
	Enchadas Island (Patent Slip)						
RIVER PLATE ..	Monte Video, Lobos Point	450	56	18	4 to 6	..	..
	Cibil el Cerro *						
	Maná (Dry Dock)	271	52	11 to 18	..	..	1881
	Colonia (Dry Dock)	..	..	8 to 9	..	..	1869
VALPARAISO ..	Floating Dock (*Valparaiso*)	260	80	15	5	..	1863
	Lift Dock (*Santiago* †)	302	90	17	..	..	1865
CALLAO	Iron Floating Dock	300 inside	100 over all, 76 inside	..	4	..	1866
PANAMA.. ..	Taboga Gridiron	320	..	16 outer end, 11 inner end	15 to 22	10 to 16	..
SAN FRANCISCO	Graving Dock, Hunter's Point	450	93	22 to 23	4½	3½ ‡	1868
	Floating Dock						
	Mare Island:—						
	Government						
	Sectional Dock	..	..	..	..	..	..
	Graving "						
ESQUIMALT ..	Graving Dock ..	400	65	26–6	7 to 10	5 to 8	Building

* Cibil el Cerro Graving Dock is now complete. Amongst other vessels, a French mail steamer, drawing over 18 feet, was docked and repaired.

† H.M.S. *Opal* was docked in the *Santiago*, December, 1876.

‡ Tides upon the coasts of California and British Columbia are of a complicated character

See page 212.

RIO JANEIRO.—At the Naval Dockyard there are two Building Slips, on which ships of 2400 and 800 tons may be built.

Coal Island Dock is better than Imperial. It is contemplated to lengthen this dock.

COALS.—Welsh and North Country coals are contracted for at £2 6s. per ton. Brought alongside in lighters at about the rate of 12 tons per hour at usual anchorage. Coaling very rapid at Enchadas Island; here ships either go alongside the coal wharves, or lie close to; 280 tons have been shipped in 7 hours.

MONTE VIDEO.—COALS.—Welsh and North Country by contract, £2 per ton delivered. Brought alongside in large lighters. About 200 tons in 24 hours; more in fine weather.

COLONIA.—The Dock is capable of landing high and dry vessels of 1000 tons burden; present length of cradle 230 feet, capable of extension; a submarine railway is attached, extending a distance into the water of 650 feet.

VALPARAISO.—The *Santiago* can dock ships of 4000 tons; the *Valparaiso*, ships of 2200 tons.

COALS.—Welsh coal by contract with P. S. N. Co. at £2 10s. per ton. Delivered alongside in lighters holding about 40 tons. Get about 200 tons a day. Lota coal can be purchased.

TALCAHUANO.—A Dry Dock is to be constructed, and to be completed in 1887.

CALLAO.—This dock is said to be capable of taking in a ship of 21 feet draught. The rates charged for ships of war per special agreement with Dock Company.

The dock cost £75,000, was constructed at Glasgow in 1865, and put together in Callao; was launched on 1st May, 1866, and named *St. George*. It can be sunk in two hours and pumped out in the same time. A wooden gate at the entrance, recently fitted, enables vessels of less than 300 feet length over all to take the blocks without apparently striking on them. This is important, as frequently at "full and change" a heavy swell sets into the bay although sheltered from the prevailing southerly winds. The *Astree*, French frigate, of about 3000 tons, was docked here in 1868.

COALS.—Welsh. Contract with P. S. N. Co. at £3 per ton. Delivered alongside in lighters holding from 30 to 50 tons. Can get about 200 tons in a day. About 1000 tons kept in store.

PANAMA.—Coaling at Taboga. Contract with P. S. N. Co., who supply Welsh coal at £4 10s. per ton, sent off in lighters containing 25 to 80 tons. Get about 200 tons a day. 500 tons always in store.

SAN FRANCISCO (CALIFORNIA).—The Graving Dock at Hunter's Point is cut in the solid rock, and will take in, at mean high tide, a vessel of 22 feet draught. Length on blocks 384 feet; breadth at top 93 feet, at bottom 60 feet; depth 30 feet. The dock has two centrifugal pumps, which will entirely free it from water in two hours. In 1870 the rate charged for the first day was 75 cents per ton, and for subsequent days 37½ cents per ton.

The Floating Dock is capable of taking up a vessel of 1500 tons.

COALS.—Welsh, Vancouver, and Australian by purchase. Delivered alongside in large schooner-rigged lighters holding about 75 tons. Price generally about $11·50 per ton. Australian coal a little less. Can get about 300 tons a day.

MARE ISLAND lies 25 miles from San Francisco. Sectional Dock in good order (except two sections), with a lifting power of 4000 tons; if complete would lift 4500 tons. A Stone Dock is being constructed 400 feet long, with 26 feet over sill.

ESQUIMALT.—COALS.—Naval Depôt, principally Nanaimo coal by contract. Sent off in large lighters, and if due notice is given, as much as is required sent off in one day.

United States, West Indies, and Canada.

Name of Port.	Dock.	Length over all.	Breadth of Entrance.	Depth over Sill, ordinary Springs.	Rise of Tide.		Date of Construction.
					Springs.	Neaps.	
		Feet.	Feet.	Feet.	Feet.	Feet.	
UNITED STATES	Savannah (Dry Dock)	345	..	18	7½	6	..
	Norfolk (Stone Dock)	281	55 46	25	3		
	Philadelphia ..	282	60		7	5¾	
	Do. ..	175					
	New York (Stone Dock)	320	70	25	5¼	4¼	
	Two Lift Docks						
	Boston (Stone Dock)	341	60	25	11½	10	
	Portsmouth ..	324–28	90		9½	8¾	
HAVANA ..	Floating Dock ..	302	85	..	3	..	..
MARTINIQUE ..	West Indies (Dry Dock)	423	85½	28½	1½	..	..
DEMERARA ..	Sproston Dock ..	230	45	11	9	6	..
ST. THOMAS ..	Patent Slip ..	..	..	8½ to 11½	1	..	..
	Floating Dock (Iron)						
HALIFAX ..	Two Patent Slips	..	..	..	6	5	..
QUEBEC	Graving Dock ..	313	..	16½ to 19	18	13	..
	Floating Dock ..	220	50	14½ to 17			
	Also Graving Dock	500	66	..	..	..	1882
ST. JOHN NEWFOUNDLAND	Simpson Dock ..	600	85	25	3¾	3¼	1884
BERMUDA ..	Iron Floating Dock	381	83·9	..	4	..	1868
	Patent Slip						

PORTSMOUTH.—Balance Dock in eight sections; lifting capacity, 3500 tons.

PHILADELPHIA.—(1) Floating Dock in nine sections; lifting capacity, 5000 tons. (2) Floating Dock in five sections; lifting capacity, 2400 tons.

HAVANA.—This Dock, moored on north shore of Harbour in 6 fathoms, is capable of receiving a vessel of 3000 tons and 20 feet draught. Dock can be pumped out in three hours.
Coals can be purchased.

MARTINIQUE.—The Dry Dock is at Fort de France. Length at water line, 410 feet; height of caisson, 34¾ feet. Time required to empty dock, 9½ hours. Vessels of war and mail steamers have priority of admission, except in the case of vessels having a leak, and really in danger. The rates charged are—first day, 2*s.* 9½*d.* sterling per ton, afterwards 8¾*d.* per ton and per diem.
Coals can be purchased.

DEMERARA.—The Dock will accommodate vessels of the largest size that frequent the port. Small repairs can be made good.

ST. THOMAS, W. I.—Patent Slip, said to be equal to 1200 tons, but only suitable for a vessel of 900 tons.
Iron Floating Dock, capable of receiving vessels of 2700 tons in weight, and 275 feet length of keel.
COALS.—The various Mail Companies have coal wharves and large Depôts of coals. Welsh and North Country coal can be purchased from Messrs. Lamb and Co., who make all arrangements for quick coaling. Lighters hold from 4 to 12 tons. Cargoes of coal hoisted and shovelled at 25 cents per ton.

HALIFAX.—The Patent Slips at Dartmouth will take vessels of about 1000 tons.
Coals can be obtained from the Dockyard.

QUEBEC.—There are eight Floating or Wet Docks, 236 to 125 feet in length; 54 to 51 feet in width, capable of taking a ship of 1800 tons. Also 5 Graidirons, and one Patent Slip for vessels under 400 tons.
The Basin constructing north of the Custom House will enclose an area of 60 acres; 40 acres to be Wet Dock, and 20 acres Tidal Basin, with minimum depths of 27 feet and 42 feet respectively at high water.

SYDNEY (CAPE BRETON).—The Patent Slip at North Sydney will take vessels of 1500 weight.
Coals can be obtained in any quantity direct from the mines. Good, but dirty. Vessels go alongside the wharves, and large quantities are put on board very quickly.

PICTOU.—The Patent Slips are capable of receiving vessels of about 500 tons.
Coal mines in the vicinity. Large vessels can lie alongside the wharves and are loaded with great despatch. At the Arcadia Company's wharf 150 tons an hour have been put on board colliers.

BERMUDA.—The length of the Dock inside is 330 feet; breadth inside, 83 feet 9 inches; depth, outside 74 feet 5 inches, inside 54 feet 5 inches. The Patent Slip, St. George's, takes vessels up to 1900 tons.
Coals can be obtained from the Naval Depôt.

AZORES.—St. Michael, Ponta Delgada. A Floating Dock capable of repairing ships of about 1500 tons was launched in 1875.
Coals can be purchased.

COALING STATIONS.

List of Places where Coals may be obtained.

Peninsula.—Corunna, Vigo, Lisbon.*

Mediterranean.—Gibraltar,* Cagliari in Sardinia, Naples, Malta,* Brindisi, Corfu, Piræus,* Smyrna, Alexandria, Port Said,* Beirut, Constantinople.*

East Indies.—Suez,* Aden,* Bombay, Galle,* Trincomalee,* Calcutta, Rangoon, Penang.

Indian Ocean.—Diego Garcia, Zanzibar,* Seychelles, Bourbon, Mauritius.*

China.—Bangkok, Saigon, Hongkong,* Amoy,* Shanghai,* Tamsui, Fuchau.

Japan.—Nagasaki,* Kobi,* Yokohama,* Hakodadi.

Malay Archipelago.—Batavia, Sourabaya, Singapore,* Labuan,* Manila.

Australia.—Perth, King George Sound, Adelaide, Melbourne, Sydney,* Brisbane.

New Zealand.—Auckland, Wellington, Christchurch, Otago.

Tasmania.—Hobartown.

Atlantic and West Coast of Africa.—Madeira,* St. Michael's, St. Vincent* (Cape de Verdes), Gambia, Sierra Leone,* Quetta,* Dix Cove,* Elmira,* Cape Coast Castle,* Whydah,* Fernando Po,* Congo,* Loando, Cape Town,* Simon's Bay,* Ascension,* St. Helena.

East Coast of South America.—Para, Maranham, Ceara, Pernambuco, Bahia, Rio de Janiero,* Monte Video,* Buenos Ayres, Falkland Islands (Port Stanley).

North America and West Indies.—St. John's, Halifax,* St. John's, N.B., Quebec, Pictou, Bermuda,* Nassau, Havana, Belize, Jamaica,* St. Thomas, Antigua, St. Lucia, Barbadoes,* Trinidad, Martinique.

Pacific Ocean.—Esquimalt,* San Francisco, San Diego, Mazatlan, Acapulco, Panama,* Guayaquil, Payta,* Callao,* Caldera,* Coquimbo,* Valparaiso,* Chiloe (Ancud), Tahiti, Levuka, Honolulu.

* Places where the British Government have established Depôts, or local contracts.

FOREIGN SEA TERMS AND PHRASES.

Sails.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Sail	Voile. *f.*	Vela. *f.*	Vela. *f.*	Segel. *n.*
Mainsail	Grand' voile. *f.*	Maestra. *f.*	Vela mayor.	Gross-Segel. *n.*
Main top-sail	Grand hunier.	Gabbia. *f.*	Gavia. *f.*	Gross-Marssegel. *n.*
Main top-gallant sail	Grand perroquet.	Gran velaccio. *m.*	Juanete mayor.	Gross-Bramsegel. *n.*
Main royal	Grand cacatois.	Controvelaccio di maestra. *m.*	Sobre juanete mayor.	Gross-Ober-Bramsegel. *n*
Fore-sail	Misaine. *f.*	Trinchetto. *m.*	Trinquete. *f.*	Fock. *f.*
Fore top-sail	Petit hunier.	Parochetto. *m.*	Velacho. *m.*	Vor-Marssegel. *n.*
Fore top-gallant sail	Petit perroquet.	Piccolo velaccio. *m.*	Juanete de proa.	Vor-Bramsegel. *n.*
Fore royal	Petit cacatois.	Controvelaccio di trinchetto. *m*	Sobre juanete de proa.	Vor-Ober-Bramsegel. *n.*
Mizen	Artimon. *m.*	Mezzana. *f.*	Mesana. *f.*	Besahn. *m.*
Mizen top-sail	Perroquet de fougue.	Contromezzana. *f.*	Sobre mesana.	Kreuz-Marssegel. *n.*
Mizen top-gallant sail	Perruche. *f.*	Belvedere. *m.*	Periquito. *m.*	Kreuz Bramsegel. *n.*
Mizen royal	Cacatois de perruche.	Controbelvedere, *m.*	Sobre periquito.	Kreuz-Ober-Bramsegel. *n.*
Fore topmast stay-sail	Petit foc.	Trinchettina. *f.*	Vela de estay de velacho.	Vor-Stenge-Stagsegel. *n*
Main stay-sail	Pouillouse. *f.*	Vela di straglio di maestra. *f.*	Vela de estay mayor.	Gross-Stagsegel. *n.*
Gaff top-sail	Voile de flèche. ou fléche. *m.*	Controranda. *f.*	Vela escandalosa *or* Cangreja *f.*	Gaffel-Topsegel. *n.*
Jib	Foc. *m.*	Fiocco. *m.*	Foque. *m.*	Klüver. *m.*
Flying jib	Clin-foc. *m.*	Controfiocco. *m.*	Petifoque. *m.*	Aussen-Klüver. *m.*
Try-sails	Voiles goelettes.	Rande. *f.*	Velas de senda.	Trie-Segel. *n.*

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Spanker	Brigantine. *f.*	Randa *or* Brigantina. *f.*	Maricangalla. *f.*	Besahn. *m.*
Lower studding sail	Bonnette basse. *f.*	Scopamare. *m.*	Rastrera. *f.*	Unter Lee-Segel. *n.*
Topmast studding-sail	Bonnette d' hune.	Coltellaccio. *m.*	Ala de gavia.	Ober-Lee-Segel. *n.*
Top-gallant studding-sail	Bonnette de perroquet.	Coltellaccino. *m.*	Ala de juanete.	Bram-Lee-Segel. *n.*
Masts, Yards, etc.				
Mast	Mât. *m.*	Albero. *m.*	Palo. *m.*	Mast. *m.*
Yard	Vergue. *f.*	Pennone. *m.*	Verga. *f.*	Raa. *f.*
Boom	Bout-dehors.	Asta. *f.*	Botalon. *m.*	Baum. *m.* Spiere. *f.*
Mainmast	Grand mât.	Albero di maestra. *m.*	Palo mayor.	Gross-Mast. *m.*
Foremast	Mât de misaine	Albero di trinchetto. *m.*	Palo de trinquete.	Fock-Mast. *m.*
Mizenmast	Mât d'artimon.	Albero di mezzana. *m.*	Palo de mesana	Kreuz-Mast. *m.* (Square Rigged.) Besahn-Mast. *m.* (Fore and Aft Rigged)
Bowsprit	Beaupré. *m.*	Bompresso. *m.*	Bauprés. *m.*	Bugspriet. *n.*
Topmast	Mât d' hune.	Albero di gabbia. *m.*	Mastelero. *m.*	Stenge. *f.*
Top-gallant mast	Mât de perroquet.	Alberetto di velaccio. *m.*	Mastelero de juanete.	Bram-Stenge. *f.*
Lower yard	Basse vergue.	Pennone maggiore *or* basso. *m.*	Verga mayor.	Unter-Raa. *f.*
Top-sail yard	Vergue d' hune	Pennone di gabbia. *m.*	Verga de gabia.	Mars-Raa. *f.*
Top-gallant yard	Vergue de perroquet.	Pennone di velaccio. *m.*	Verga de juanete	Bram-Raa. *f.*

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Royal yard	Vergue de cacatois.	Pennone di contrevelaccio. *m.*	Verga de sobre juanete.	Ober-Bram-Raa. *f.*
Top	Hune. *f.*	Coffa. *f.*	Cofa. *f.*	Mars. *m.*
Topmast cross-trees	Barres de perroquet.	Crocette. *f.*	Crucetas. *f.*	Bram-Saling. *f.* Quer-Saling. *f.*
Cap	Chouquet ou chouque. *m.*	Testa di moro. *f.*	Tamborete. *m.*	Eselshaupt. *n.*
Truck	Pomme du mât.	Pomo *or* Galletta	Perrilla. *f.*	Flaggen-Knopf. *m.*
Jib-boom	Bâton ou bout-dehors de foc.	Asta di fiocco. *f.*	Botalon de foque.	Klüverbaum. *m.*
Studding-sail boom	Bout-dehors de bonnette.	Asta di coltellaccio. *f.*	Botalon de ala.	Lee-Segel-Spiere. *f.*

Miscellaneous.

Ship	Navire, bâtiment. *m.*	Nave. *f.*	Buque. *m,*	Schiff. *n.*
Deck	Pont. *m.*	Ponte. *m.*	Cubierta. *f.*	Deck. *n.* Verdeck. *n.*
Hold	Cale. *f.*	Stiva. *f.*	Bodega. *f.*	Raum. *m.*
Cabin	Chambre *or* Cabine. *f.*	Camera. *f.* camerino. *m.*	Cámara. *f.*	Kammer *f.* Kajüte. *f.*
Windlass	Guindeau. *m.*	Verricello. *m.*	Molinete. *m.*	Bratspill. *n.*
Capstan	Cabestan. *m.*	Argano. *m.*	Cabrestante. *m.*	Gangspill. *n.*
Bitts	Bittes. *f.*	Bitte. *f.*	Bitas. *f.*	Beting. *f.*
Compass	Boussole. *f.* Compas. *m.*	Bussola. *f.*	Aguja. *f.* Compás. *m.*	Kompass. *m.*
Helm	Barre. *f.*	Barra (del timone.) *f.*	Timon. *m.*	Steuer. *n.*
Anchor	Ancre. *f.*	Ancora. *f.*	Ancla. *f.*	Anker. *m.*
Cable	Câble. *m.*	Gomena *or* catena. *f.*	Cable *m* Cadena. *f*	Ankertau. *n.* Anker-Kette. *f.*
Forward	A l'avant.	A prua.	A proa.	Vorne.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Aft	A l'arrière.	A poppa.	A popa.	Hinten. Achter.
Fore and aft	De l'avant à l'arrière.	Prua e poppa.	De proa á popa.	Vorne bis hinten.
Athwart	En travers.	Al traverso.	Por el traves.	Dwars. Quer.
Hawser	Aussiére. *f.*	Gherlino. *m.*	Guindaleza. *f.*	Trosse. *f.*
Starboard	Tribord. *m.*	Dritta. *f,*	Estribor.	Steuerbord.
Larboard (port)	Babord. *m.*	Sinistra. *f.*	Babor.	Backbord.
Below	En bas.	Abbasso.	Abajo.	Unten.
Aloft	En haut.	Arriva.	Arriba.	Oben.
Avast	Tenez bon.	Basta. Alla voce!	Forte!	Stopp. Fest.
Shrouds	Haubans. *m.*	Sartie. *f.*	Obenques. *m.*	Wanten. *f.*
Stay	Etai. *m.*	Straglio. *m.*	Estay. *m.*	Stag. *n.*
Backstays	Galhaubans. m.	Paterazzi. *m.*	Brandales. *m.*	Pardunen. *f.*
Bobstay	Sous-barbe. *f.*	Briglia. *f.*	Barbiquejo. *m.*	Wasser-Stag. *n.*
Lanyards	Rides. *f.*	Corridori. *m.*	Acolladares. *m.*	Taljereep. *n.*
Tackle	Palan. *m.*	Paranco. *m.*	Aparejo. *m.*	Takel. *m.*
Braces	Bras. *m.*	Bracci. *m.*	Brazas. *f.*	Brassen. *f.*
Tack	Amure. *f.*	Mura. *f.*	Amura. *f.*	Hals. *m.*
Sheet	Ecoute. *f.*	Scotta. *f.*	Escota. *f.*	Schoot. *n.*
Haulyards	Drisse *f.*	Drizza. *f.*	Driza. *f.*	Fall. *n.*
Downhaul	Hale-bas. *m.*	Alabbasso. *m.*	Cargadera. *f.*	Niederholer. *m.*
Clewlines	Cargues-pointa *f*	Caricascotte. *f.*	Chafaldetes. m.	Geitaue. *n.*
Buntlines	Cargues-fonds *f.*	Caricamezzi. *m.*	Brioles. *m.*	Buggording. *n.*
Brails	Cargues. (de voiles auriques.) *f.*	Imbrogli. *m. or* Cariche. *f.*	Candelizas. *f.*	Geitaue. *n.*
Reeftackles	Palanquins. *m.*	Paranchi di terzarolo. *m.*	Palanquines de rizos.	Refftaljen. *f.*
Bowline	Bouline. *f.*	Bolina. *f.*	Bolina. *f.*	Bulien. *f.*

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Gasket	Jarretière. *f.* Raban de ferlage.	Gerli. *m.*	Tomador. *m.*	Beschlag-Zeising. *m.*
Crew	Equipage. *m.*	Equipaggio. *m.*	Tripulacion. *f.*	Mannschaft. *f.*
Boatswain	Maître d'équipage ou maître de manœuvre.	Nocchiere. *m.*	Contramaestre.	Bootsmann. *m.*
Sailmaker	Voilier. *m.*	Velaio. *m.*	Maestro de velas	Segelmacher. *m.*
Carpenter	Charpentier. *m.*	Carpentiere. *m.*	Carpintero. *m.*	Schiffszimmermann. *m.*
Steward	Commis aux vivres.	Dispensiere *or* Commesso. *m.*	Despensero.	Steward. *m.*
Cook	Cuisinier. *m.*	Cuoco. *m.*	Cocinero	Koch. *m.*
Seaman	Matelot. *m.*	Marinaro. *m.*	Marinero.	Matrose. *m.*
Boy	Mousse. *m.*	Mozzo. *m.*	Joven Mozo. *m.*	Junge. Schiffsjunge. *m.*
Belay	Amarrez.	Volta.	Amarra.	Belegen.
Let go	Larguez.	Molla.	Largo.	Los.
Hoist away	Hissez.	Alza.	Iza!	Hissen. Aufhissen.
Lower away	Amenez.	Ammaina.	Arria.	Streichen, fieren.
Haul	Hâlez.	Ala.	Hala!	Holen.
Handsomely	En douceur.	Adagio.	Poco á poco.	Langsam.
Hold on	Tenez bon dessus.	Agguanta.	Aquanta.	Fest. Halt an.
Heave away	Virez.	Gira *or* Vira.	Vira!	Dreh rund.
Slack	Filez, mollissez.	Fila.	Arria!	Beifieren, Losen.
Bear a hand	Vite, rondement	Presto.	Pronto ! echa una mano.	Schnell.
Boat	Canot, *m.* embarcation. *f.*	Lancia *or* Imbarcazione. *f.*	Bote. *m.*	Boot.
Oar	Aviron. *m.*	Remo. *m.*	Remo. *m.*	Riemen. *m.*
Baler	Escope. *f.*	Sassola. *f.*	Vertedor. *m.*	Ausholer. *m.*

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Clear	Clair.	Chiaro, libero, Scapolo.	Claro.	Klar.
Foul	Engagé.	Impegnato.	Enredado.	Unklar.
Windward	Au vent.	Sopravento.	Barlovento.	Luffwärts.
Leeward	Sous le vent.	Sottovento.	Sotavento.	Leewärts.
Catch hold	Attrapez.	Afferrare, agguantare.	Agarra !	Nehmen Sie es.
Look out	Veille, vigie. Faire bonne veille.	Scoperta, vedetta. Buona guardia.	Guarda.	Ausguck. *m.* Gebt Acht.
All right	C'est bien.	Va bene.	Bueno.	Gut so.
		Phrases.		
Heave away the capstan	Virez au cabestan.	Gira l'argano.	Vira al cabrestante.	Dreh rund das Gangspill.
Sheet home the top-sails	Bordez les huniers.	Borda le gabbie.	Caza a besar los escotines de las gavias.	Schoot vor die Marssegel.
Hoist the top-sails	Hissez les huniers.	Alza le gabbie.	Iza gavias.	Hissen Sie die Marssegel.
Hoist the top-gallant sails	Hissez les perroquets.	Alza i velacci.	Iza juanetes.	Hissen Sie die Bramsegel.
The anchor is aweigh	L'ancre est dérapée.	L'ancora ha lasciato.	El ancla ha largado.	Der Anker ist gelichtet.
Hoist the jib	Hissez le foc.	Alza il fiocco.	Iza foque.	Hiesen Sie den Klüver
Fill the head sails	Mettez le vent dans les voiles de l'avant.	Riempite o fate portare le vele di prora.	Biaza en viento las velas de proa	Füllen Sie die Vorsegel
Set the main-sail	Établissez la grand' voile.	Murate la maestra.	Echa la vela mayor.	Füllen *or* Setzen Sie das Gross-Segel.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Ready about	Pare à virer.	Pronti a girare.	Alista á virar.	Klar zum wenden.
Helm's a-lee	La barre dessous.	Sotto la barra.	Orza á la banda	Loss Vorshoeten.
Raise tacks and sheets	Levez les lofs.	Smura.	Levanta puños sobre bolinas.	Auf Halsen.
Mainsail haul	Changez derrière	Controbraccia *or* cambiaa poppa.	Cambia al medio	Rund achtern.
Let go and haul	Changez devant.	Controbraccia *or* camba a prora.	Descarga á proa	Rund vorne.
Brace sharp up	Brassez au plus près.	Bracciate a segno.	Braza bien á ceñir.	Brassen Sie scharf an.
Square the yards	Brassez carré.	Bracciate in croce.	Braza en cruz.	Brassen Sie Vierkant.
Hard up the helm	La barre au vent toute.	Barra sopravento *or* Poggia tutto.	Anda todo—Todo de arribada.	Ruder hart auf.
Steady the helm	Droite la barre, ou comme à.	Alla via ! Via !	Caña á la via.	Halt an *or* recht so.
Up mainsail	Carguez la grand' voile.	Imbrogliate la maestra.	Carga la rela mayor.	Gei auf Gross-Segel.
Round in the weather braces	Brasser au vent *or* Fermer les vergues.	Alate i bracci di sopravento.	Afirma á barlovento.	Brassen Sie auf.
Haul down the jib	Hâlez bas le foc.	Alabbasso il fiocco.	Arria foque.	Holen Sie den Klüver nieder.
Up foresail	Carguez la misaine.	Imbrogliate il trinchetto.	Carga trinquete.	Gei auf die Fock.
Back the main-topsail	Brassez le grand hunier à culer ou masquez le grand hunier.	Bracciate a collo la gabbia.	Ponga la gavia por delante ; Ponga en facha Li gavia.	Legen Sie das Gross-Mars-Segel back.

Words of Command in Tacking.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Let go the anchor	Mouillez.	Date fondo Fondo !	Fondo al ancla.	Lass fallen den Anker.
Clew up the top-sails	Carguez les huniers.	Imbrogliate le gabbie.	Carga gavias.	Gei auf die Marssegel.
Brail the spanker up	Carguez la brigantine.	Imbrogliate la randa.	Carga la cangreja.	Gei auf den Besahn.
Pay out the cable	Filez de la chain.	Filate la catena.	Fila cadena ; Fila cable ; Arria cadena.	Stecken Sie die Kette.
Furl the sails	Serrez les voiles.	Serrate le vele.	Aferra el velámen.	Machen Sie die Segel fest.
Hoist the ensign	Hissez le pavillon.	Alzate la bandiera.	Iza la bandera.	Hissen Sie die Fahne auf.
Coil the ropes up	Lovez les manœuvres.	Raccogliete la manovra.	Aduja los cabos.	Schiessen Sie die Reepen auf.
Right the helm	Dressez la barre.	Barra in mezzo.	Caña á la via ; Caña al medio.	Mitt-schiffs. Lassen Sie das Steuer aufgehen.
Ship ahoy !	Ho du navire !	Oh! della nave.	Ah del buque.	Schiff ohoy ?
What ship is that ?	Quel est le nom du navire. ?	Come si chiama la nave?	¿ Como se llama el buque ?	Wie heisst das Schiff ?
Where are you from ?	D'où venez vous?	Donde venite?	¿ De donde viene?	Woher sind Sie ?
Where are you bound to ?	Où allez vous?	Dove siete diretto ?	¿ Adonde va. V. ? (V. Usted).	Wo gehen Sie hin ?
How many days out ?	Combien de jours en route ?	Quanto tempo in viaggio ?	¿ Cuántos dias de navegacion ?	Wie lange sind Sie in See ?
Please to report me	Dites que vous m'avez rencontré	Vi prego annunziarmi.	¿ Quiere. V. anunciarme ?	Melden Sie mich gefälligst.
Ship's papers	Papiers de bord	Documenti della nave. *m.*	Los papeles del buque.	Schiffs papiere.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.
Register	Registre. *m.*	Patente di navigabilità. *f.*	Registro de construccion.	Register. *n.*
Bills of lading	Connaissements.	Polizza di carico.	Conocimientos.	Verladungs Schein. *m.*
Manifest	Manifeste. *m.*	Manifesto. *m.*	Manifiesto. *m.*	Manifest. *n.*
Bill of health	La patente de santé.	Patente di sanità. *f.*	Patente de sanidad. Fé de S.	Gesundheitspass. *m.*
Log book	Journal du bord. *m.*	Quaderno di chiesuola. *m.*	Cuaderno de bitá cora. Libro de sobordo.	Loggbuch. *n.* Bord-Journal. *n.*

CONVERSION TABLES

OF

EQUIVALENT WORDS, LETTERS, AND FIGURES.

Arranged for Telegraphing, for Reduction, and for Comparison; and for Reporting Meteorological Observations.

Equivalents for French Words descriptive of Weather, and State of the Sea.

Beau - - - - -	Fine - - - - -	b*
Belle - - - - -	Smooth, still -	—
Brouillard - - -	Fog - - - - -	f
Brumeux-se - - -	Foggy - - - -	g
Ciel - - - - -	Sky - - - - -	—
Clair-e - - - -	Clear - - - - -	v
Couvert-e - - -	Overcast - - -	o
Coup (de vent) -	Heavy squall - -	q q or q l
Éclair - - - - -	Lightning - - -	
Éclaireux-se - - -	Lightning around -	ll or l
Faible - - - - -	Light, slight - - -	—
Fort-e - - - - -	Much, strong - -	(—, or ·, or repetition.)
Grains - - - - -	Squally - - - -	q or q
Grand-e - - - -	Great, much - -	(—, or ·, or repeated letter)
Humide-ité - - -	Damp, humidity - -	—

* Letters, etc., for the Beaufort Notation, see page 109.

Equivalents for French Words—(*continued*).

		(¯, or ·, or a repetition.)
Intense-ité - - -	Intense-ity - - -	
Lægér-e-ment - - -	Light-ly - - - -	— *
Mauvais-e - - -	Bad, threatening - -	u
Nebeleux-se - - -	Misty, hazy, obscure -	m
Neige-ant - - -	Snow-ing - - -	s
Nuage-s-eux-se - -	Cloud-s-y - - -	c
Orage-ux - - -	Storm-y - - -	q
Pluie-s - - - -	Rain-s - - - -	rr
Pluvieux-se - - -	Rainy - - - -	r
Presque - - - -	Almost, slight - - -	—
Rafales - - -	Sudden squalls - -	q
Serein-e - - - -	Serene, settled - -	b c
Sombre - - -	Gloomy, dark - -	g or gg
Tempête - - - -	Tempest - - - -	qq
Tempestueux-se - -	Tempestuous - -	—
Tonnerre - - -	Thunder - - - -	t
Tonnant-e - - -	Thundery - - -	t t
Très - - - -	Very, excessively - -	(¯, or ·, or a repetition.)
Calme - - - -	Dead calm - - -	
Assez calme - - -	Calm - - - -	
Très belle - - -	Very smooth - -	
Belle - - - -	Smooth - - - -	

* Letters, etc., for the Beaufort Notation, *see* page 109.

Equivalents for French Words—(*continued*).

Tranquille	Still
Faible houle	Slight swell
Petite houle	" "
Un peu houleuse	Some swell
Un peu de mer	Rather rough
Clâpoteuse	Squally
Agitée	Disturbed irregularly
Houleuse	Considerable swell
Très houleuse	Much swell
Moutonnese	Crested waves
Creusée	Cross sea
Grosse houle	Great swell
Haute mer	High sea
Très-grosse mer	Very large and high sea

FOREIGN TERMS FOR WINDS, etc.

North.—*Tramontana* and *Gli Secchi*, or dry winds, by the Italians.

N.E.—The *Gregale* of the Italians and Maltese; the *Bora* of the Adriatic.

East.—*Solano* and *Levanter* of the Straits; *Levante; Bentu de Sole;* and when light, *Chocolatera* by the Italians.

S.E.—*Scirocco*, the hot debilitating wind of South Italy and Africa; *Maledetto, Levante, Molezzo*, and in the Adriatic, when strong, *Furiante.*

South.—*Mezzo Giorno;* from S. to S.W. *Simoom, Shume* or *Siume*, on the African Coast.

S.W.—*Vendavales;* also *Lebeches*, and *Virazones*, by the Spanish *Libeccio;* when gusty, *Labeschades;* and when very stormy, accompanied by lightning, rain, etc., it is called *Ouragans*, by the Italians. *Labbetch*, in Algeria: and *Siffanto* in the Adriatic.

West.—It is called in the Straits of Gibraltar the *Liberator. Ponente* (strong) by the Italians.

N.W.—The *Mistral, Mistrau*, the *Bize*, and *Grippe*, also the *Vent de cers* of France. *Maestro, Maestrale*, of the Italians; and when light it is called *Mamatete* by the Sicilians.

N.N.W.—*Provenzale* by the Italians of Livorno.

A Sea Breeze.—*Imbattu.*

A Land Breeze.—*Vento di Terra* or *Rampinu.*

Land Squalls.—*Raggiature* by the Italians.

Mountain Storms.—*Burrasche*, South Italy, and *Raffiche* in Corsica.

Golfada, a hard gale. *Bonaceia*, calms between land and sea breezes in Italy.

The meeting of opposing winds is called *Contrastes* by the Spaniards.

Mariner's Compass of Various Nations.

ENGLISH.	FRENCH.	ITALIAN.	SPANISH.	GERMAN.	DUTCH.	SWEDISH, NORWEGIAN DANISH.
NORTH	Nord	Tramontana	Norte	Nord	Noord	Nord
N. b E.	N. q. N.E.	T. quarto G.	N. cuarto N.E.	N. zu O.	N. ten O.	N. til O.
N.N.E.	N.N.E.	G.T.	N.N.E.	N.N.O.	N.N.O.	N.N.O.
N.E. b N.	N.E. quart N.	G. quarto T.	N.E. cuarto N.	N.O. zu N.	N.O. ten N.	N.O. til N
N.E.	N.E.	Greco	N.E.	N.O.	N.O.	N.O.
N.E. b E.	N.E. quart E.	G. quarto L.	N.E. cuarto E.	N.O. zu O.	N.O. ten O.	N.O. til O
E.N.E.	E.N.E.	G.L.	E.N.E.	O.N.O.	O.N.O.	O.N.O.
E. b N.	E. quart N.E.	L. quarto G.	E. cuarto N.E.	O. zu N.	O. ten N.	O. til N.
EAST	Est	Levante	Este	Ost	Oost	Ost
E. b S.	E. quart S.E.	L. quarto S.	E. cuarto S.E.	O. zu S.	O. ten Z.	O. til S.
E.S.E.	E.S.E.	S.L.	E.S.E.	O.S.O.	O.Z.O.	O.S.O.
S.E. b E.	S.E. quart E.	S. quarto L.	S.E. cuarto E.	S.O. zu O.	Z.O. ten O.	S.O. til O.
S.E.	S.E.	Scirocco	S.E.	S.O.	Z.O.	S.O.
S.E. b S.	S.E. quart S.	S. quarto O.	S.E. cuarto S.	S.O. zu S.	Z.O. ten Z.	S.O. til S.
S.S.E.	S.S.E.	O.S.	S.S.E.	S.S.O.	Z.Z.O.	S.S.O.
S. b E.	S. quart S.E.	O. quarto S.	S. cuarto S.E.	S. zu O.	Z ten O.	S. til O.
SOUTH	Sud	Ostro	Sur	Sud	Zuid	Syd
S. b W.	S. quart S.O.	O. quarto L.	S. cuarto S.O.	S. zu W.	Z. ten W.	S til V.
S.S.W.	S.S.O.	O.L.	S.S.O.	S.S.W.	Z.Z.W.	S.S.V.
S.W. b S.	S.O. quart S.	L. quarto O.	S.O. cuarto S.	S.W. zu S.	Z.W. ten Z.	S.V. til S
S.W.	S.O.	Libeccio	S.O.	S.W.	Z.W.	S.V.
S.W. b W.	S.O. quart O.	L. quarto P.	S.O. cuarto O.	S.W. zu W.	Z.W. ten W.	S.V. til V.
W.S.W.	O.S.O.	P.L.	O.S.O.	W.S.W.	W.Z.W.	V.S.V.
W. b S.	O. quart S.O.	P. quarto L.	O. cuarto S.O.	W. zu S.	W. ten Z.	V. til S.
WEST	Ouest	Ponente	Oeste	West	West	Vest
W. b N.	O. quart N.O.	P. quarto M.	O. cuarto N.O.	W. zu N.	W. ten N.	V. til N.
W.N.W.	O.N.O.	P.M.	O.N.O.	W.N.W.	W.N.W.	V.N.V.
N.W. b W	N.O. quart O.	M. quarto P.	N.O. cuarto O.	N.W. zu W.	N.W. ten W.	N.V. til V.
N.W.	N.O.	Maestro	N.O.	N.W.	N.W.	N.V.
N.W. b N	N.O. quart N.	M. quarto T.	N.O. cuarto N.	N.W. zu N.	N.W. ten N.	N.V. til N
N.N.W.	N.N.O.	M.T.	N.N.O.	N.N.W.	N.N.W.	N.N.V.
N. b W.	N. quart N.O.	T. quarto M.	N. cuarto N.O.	N. zu W.	N. ten W.	N til V.

In the French Compass the abbreviation is q as N. q N.E. or N¼ N.E.
" Italian " " q as T. q G. or T. ¼ G.
" Spanish " " c as N. c N.E. or N. ¼ N.E
" German " " z as N. z O
" Dutch " " t as N. t O.
" Swedish, Norwegian, Danish " " t as N. t O.
} equivalent to the English by.

Mariner's Compass of Various Nations—(*continued*).

ENGLISH.	CHINESE, SHANGHAI, AND NING-PO.	JAPANESE.	GREEK.	HINDOSTANEE.	TURKISH.
North	Póh	Kita	O. Borras	Guy	Yeldiz
N.E.	Tóng Póh	Higachi Kita	O. Mesēs	Guy weejow Arkrop	Porias
East	Tóng	Higachi	O. Apēliōtēs	Mutly	Gun-doghûsû
S.E.	Tóng-nen	Higachi minami	O. Euros	Sooly dow Arkrop	Ketsehichleme
South	Nén	Minami	O. Notos	Sooly	Kible
S.W.	Si-nèn	Michi minami	O. Lips? Libas?	Sooly weejow Arkrop	Lodos
West	Si	Nichi	O. Zephuros	Cably	Bâti
N.W.	Si-póh	Nichi Kita	O. Skirôn	Guy dow Arkrop	Kavayel

The Russians generally use the English or Dutch Compass.

Table of Hand-Masts.

Letter.	Hands.	Length.		Diameter at — Distance from butt, allowing 8 in. to each "hand" as given in column 2.		Diameter at — Distance from top, allowing 4 in. to each yard of "length" as given in column 3.	
		Ft.	in.	Inches.	Ft. in.	Inches.	Ft. in.
N	18	74	0	22 7/8	12 0	15 1/2	8 2
M	17 1/2	72	6	22 1/8	11 8	14 3/4	8 0
	17	71	0	21 3/8	11 4	14 1/4	7 10
L	16 1/2	69	6	21	11 0	14	7 8
	16	68	0	20 3/8	10 8	13 1/2	7 6
K	15 1/2	66	6	19 3/4	10 4	13 1/4	7 4
	15	65	0	19 1/8	10 0	12 3/4	7 2
I	14 1/2	63	6	18 1/2	9 8	12 3/8	7 0
	14	62	0	17 7/8	9 4	11 7/8	6 10
H	13 1/2	60	6	17 1/4	9 0	11 1/2	6 8
	13	59	0	16 1/2	8 8	11	6 6
G	12 1/2	57	6	15 7/8	8 4	10 3/4	6 4
	12	56	0	15 1/4	8 0	10 1/4	6 2
F	11 1/2	54	6	14 5/8	7 8	9 3/4	6 0
	11	53	0	14	7 4	9 3/8	5 10
E	10 1/2	51	6	13 3/8	7 0	8 7/8	5 8
	10	50	0	12 7/8	6 8	8 1/2	5 6
D	9 1/2	46	6	12 1/4	6 4	8	5 2
	9	45	0	11 3/8	6 0	7 5/8	5 0
C	8 1/2	43	6	10 7/8	5 8	7 1/4	4 10
	8	42	0	10 1/4	5 4	6 7/8	4 8
B	7 1/2	40	6	9 5/8	5 0	6 3/8	4 6
	7	39	0	9 1/8	4 8	6 1/4	4 4
A	6 1/2	37	6	8 1/2	4 4	5 1/2	4 2
	6	36	0	7 7/8	4 0	5	4 0

Hand-masts should be straight grown, and free from heart-shake and injurious knots.

The above table will serve, with a slight modification of the hands to the *length*, for Dantzic Fir, Canada Red Pine, and also for Virginia Pitch Pine, *due regard* being paid to the difference of the quantity of sap-wood on each *compared* with Riga Fir.

ROPE MAKING.

Rope.	What made from.	How laid up.
Yarns	Hemp	Right-handed.
Strands	Yarns	Left or right-handed.
Hawser-laid rope	3 strands	Opposite way to the strands.
Shroud-laid rope	4 strands and a heart	Right-handed.
Cable-laid rope	3 hawser-laid ropes	Left-handed.
Spunyarn	3 to 9 yarns	Right-handed.
Sennit	Yarns	Plaited.
Nettle stuff	2 or 3 left-handed yarns	Right-handed.
Foxes	Short yarns laid up by hand	Left-handed.

Rope is measured by its circumference, and is manufactured in lengths of 113 fathoms, and in different sizes, up to 28 inches; it is made up in coils up to 5-inch; above that it is sent on board in the length.

Running rigging is hawser-laid, right-handed.

A four-stranded rope is about one-fifth weaker than a three-stranded one.

Wire rope usually consists of 6 strands round a hempen core; each strand consists of 6 wires round a smaller hempen core; 36 wires in all.

Coir rope is equal in strength to hempen rope of the same size, and is but two-thirds the weight.

Two men can worm and serve seven fathoms of 3½-inch rope in an hour, or worm, parcel, and serve 3 fathoms of 7-inch in an hour.*

Three men can worm, parcel, and serve 2 fathoms of 12-inch in an hour.

One man can make 9 feet of 9-yarn sennit in an hour.

Six men can make an Elliott's eye in a 24-inch cable in one day.

The strength of a yarn may be called in round numbers 100 lbs.

* Boyd.

Proportionate Strength of Rope of Different Sizes.

To find what number of parts of a small rope are equal to a large rope.

Divide the square of the circumference of the larger rope, by the square of the circumference of the smaller; and the result will be the number of parts of the smaller equal to the larger.

Practical rule for ascertaining the strength of rope (hawser-laid).

Square the circumference, and divide by 3 for the breaking strain, in tons; by 4 for the proof strain; by 6 for the working strain.

To find what weight a rope will lift when rove as a tackle.

Multiply the weight the rope is capable of suspending by the number of parts at the movable block, and subtract one-fourth of this for resistance.

To determine the relative strength of chain and rope.

Consider the proportional strength to be 10 to 1, using the diameter of the chain and the circumference of the rope. Half-inch chain may replace 5-inch rope.

Rule for calculating the weight of rope.

Three strand, hawser-laid, 25-thread yarn, tarred. Multiply the square of the circumference by the length in fathoms, and divide by 4·24 for the weight in lbs.

The divisor for hempen cables is 4·79.

Table of Size of Rope Stropping.

Blocks.	Rope.	Blocks.	Rope.	Blocks.	Rope.	Blocks.	Rope.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
5	1	10	3	15	5	20	7
6	1½	11	3½	16	5	21	8
7	2	12	4	17	6		
8	2½	13	4½	18	6		
9	2½	14	5	19	7		

Table showing the Sized Chain or Wire Rope which is used as a Substitute for Hempen Rope.

Hemp.	Chain.	Wire.	Hemp.	Chain.	Wire.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
3	$\frac{5}{16}$	1½	8	$\frac{7}{8}$	3½
4	$\frac{3}{8}$	1¾	9	1	4
5	$\frac{1}{2}$	2	10	1⅛	4½
6	$\frac{5}{8}$	2½	11	1¼	5
7	$\frac{3}{4}$	3			

Table showing Weight of Cablets, and Cables, of 101 Fathoms; with Cordage.

Size.	Weight.			Size.	Weight.		
Inches.	cwt.	qrs.	lbs.	Inches.	cwt.	qrs.	lbs.
2	1	0	1	14½	39	0	24
2½	1	1	11	15	42	0	12
3	1	3	20	15½	44	2	2
3½	2	2	8	16	47	2	8
4	3	0	24	16½	50	3	4
4½	3	3	12	17	54	0	0
5	4	3	8	17½	56	3	16
5½	5	3	4	18	60	1	20
6	6	3	0	18½	63	2	16
6½	7	2	24	19	67	0	20
7	9	0	0	19½	70	2	24
7½	10	1	4	20	74	2	8
8	11	3	16	20½	78	0	20
8½	12	2	0	21	82	1	4
9	15	0	12	21½	86	0	16
9½	16	2	24	22	90	1	8
10	18	2	16	22½	94	2	0
10½	20	2	8	23	98	2	20
11	22	2	0	23½	102	3	12
11½	24	3	0	24	107	1	12
12	27	0	0	24½	111	3	12
12½	28	3	20	25	116	2	20
13	31	2	0	25½	121	0	20
13½	34	0	8	26	126	0	0
14	36	2	16				

Hawser-laid Rope, Coils 113 Fathoms.

2	0	3	21	7	11	2	17
2½	1	0	22	7½	13	1	13
2¾	1	1	23	8	15	1	0
2¾	1	3	5	8½	17	0	25
3	2	0	16	9	19	1	4
3½	2	3	18	9½	21	2	1
4	3	3	2	10	23	3	8
4½	4	3	5	10½	26	0	25
5	5	3	18	11	28	3	5
5½	7	0	22	11½	31	1	23
6	8	2	8	12	34	1	4
6½	10	0	3				

Bullivant's Patent Flexible Steel Wire Hawsers and Cables compared with Hemp and Chain.

PATENT FLEXIBLE STEEL WIRE HAWSERS AND CABLES.				CHAIN CABLE.				TARRED HEMP ROPE.		
Size Circumference.	Weight per Fathom.	Guaranteed Breaking Strain.	Diameter of barrel or sheave round which it may be worked.	Size.	Weight per Fathom.	Proof Strain.	Breaking Strain.	Size.	Weight per Fathom.	Breaking Strain.
Inches.	lbs.	Tons.	Inches.	Inches.	lbs.	Tons.	Tons.	Inches.	lbs.	Tons.
12	115	320	72							
11	97	270	66							
10	80	220	60							
9	65	180	54							
8	53	150	48	$2\frac{5}{16}$	280	$96\frac{1}{4}$	$134\frac{3}{4}$	25	146	125
$7\frac{1}{2}$	47	130	45	$2\frac{3}{16}$	256	$86\frac{1}{2}$	$120\frac{1}{2}$	24	134	115
7	41	116	42	$2\frac{1}{16}$	231	$76\frac{1}{2}$	$107\frac{1}{16}$	23	123	106
$6\frac{1}{2}$	37	102	39	$1\frac{13}{16}$	204	$67\frac{1}{2}$	$94\frac{1}{2}$	21	106	89
6	33	88	36	$1\frac{3}{4}$	166	$55\frac{1}{2}$	$77\frac{1}{2}$	19	84	72
$5\frac{1}{2}$	28	74	33	$1\frac{5}{8}$	143	$47\frac{1}{2}$	$66\frac{1}{2}$	17	67	60
5	$23\frac{1}{2}$	64	30	$1\frac{1}{16}$	112	$37\frac{1}{2}$	$55\frac{1}{2}$	15	56	50
$4\frac{1}{2}$	15	39	27	$1\frac{1}{4}$	68	$22\frac{3}{4}$	$34\frac{1}{2}$	13	39	34
4	12	33	24	1	54	18	27	12	33	29
$3\frac{1}{2}$	9	26	21	$\frac{15}{16}$	48	$15\frac{5}{16}$	$23\frac{7}{16}$	11	28	$24\frac{1}{2}$
$3\frac{1}{4}$	8	22	$19\frac{1}{2}$	$\frac{7}{8}$	35	$11\frac{1}{2}$	$17\frac{5}{16}$	10	23	20
3	7	18	18	$\frac{13}{16}$	30	$10\frac{1}{2}$	$15\frac{1}{16}$	9	19	$16\frac{1}{2}$
$2\frac{3}{4}$	$5\frac{1}{2}$	15	$16\frac{1}{2}$	$\frac{11}{16}$	25	$8\frac{1}{2}$	$12\frac{3}{4}$	$8\frac{1}{2}$	$16\frac{1}{2}$	14
$2\frac{1}{2}$	$4\frac{1}{2}$	12	15	—	—	—	—	$7\frac{1}{2}$	13	$11\frac{1}{2}$
$2\frac{1}{4}$	$3\frac{3}{4}$	9	$13\frac{1}{2}$	$\frac{10}{16}$	21	7	$9\frac{1}{2}$	$6\frac{1}{2}$	$11\frac{1}{2}$	10
2	$2\frac{1}{4}$	7	12	—	—	—	—	$5\frac{1}{4}$	9	8
$1\frac{3}{4}$	2	$5\frac{1}{2}$	$10\frac{1}{2}$	$\frac{9}{16}$	17	$5\frac{1}{2}$	$7\frac{1}{4}$	5	$6\frac{1}{2}$	6
$1\frac{1}{2}$	$1\frac{3}{4}$	4	9	—	—	—	—	4	4	4
$1\frac{1}{4}$	1	$2\frac{1}{2}$	$7\frac{1}{2}$	$\frac{1}{2}$	14	$4\frac{1}{2}$	6	$3\frac{1}{4}$	3	$2\frac{3}{4}$
1	$\frac{3}{4}$	$1\frac{3}{4}$	6	—	—	—	—	$2\frac{1}{4}$	2	$1\frac{1}{4}$

Where the rope only passes over a sheave, the diameter of the sheave may be one-sixth less than where the rope takes an entire turn round.

In all cases the diameter of both barrels and sheaves should be as large as practicable.

CHAIN CABLES.

Scale of Proofs showing the Tensile Strain to which Chain Cables are subjected before being received for the use of her Majesty's Naval Service.

Diameter of Iron of Common Links.	Common Links. Mean Length six diameters of the Iron; not to be over more than $\frac{1}{10}$ of a diameter.	Common Links. Mean Width 3·6 diameters of the Iron; not to be over or under more than $\frac{1}{15}$ of a diameter.	Stay Pins, weight of each not to exceed	Weight of 100 fathoms of Cable, in eight lengths, including four swivels and eight joining shackles, not to be exceeded by more than $\frac{1}{20}$th part.*	Weight by which to be proved equal to 630 lbs. per circular $\frac{1}{8}$ inch.	Strain to be withstood by three links in each fifteen fathoms, before the fifteen fathoms are proved.
Inches.	Inches.	Inches.	Ozs.	Cwt. qrs. lbs.	Tons.	Tons.
2¾	16½	9·9	72	363 0 0	136½	190·5
2½	15	9·0	54·69	300 0 0	112½	157·5
2⅜	14¼	8·55	47·5	270 3 0	101⅛	142
2¼	13½	8·1	40	243 0 0	91⅛	127·5
2⅛	12¾	7·65	33·584	216 3 0	81¼	113·75
2	12	7·2	28	192 0 0	72	100·8
1¾	11½	6·75	23	168 3 0	63½	88·5
1¾	10½	6·3	18·76	147 0 0	55⅛	77
1⅝	9¾	5·85	15	126 3 0	47⅛	66·5
1½	9	5·4	11·81	108 0 0	40½	60·75
1⅜	8¼	4·95	9	90 3 0	34	51
1¼	7½	4·5	6·839	75 0 0	28⅛	49
1⅛	6¾	4·05	4·983	60 3 0	22½	34·12
1	6	3·6	3·5	48 0 0	18	27
⅞	5¼	3·15	2·344	36 3 0	13½	20·6
¾	4½	2·7	1·473	27 0 0	10⅛	15
11/16	4⅛	2·475	1·137	22 2 21	8½	12·75
⅝	3¾	2·25	·854	18 3 0	7	10·5
9/16	3⅜	2·025	·622	15 0 21	5½	8·25
½	3	1·8	·437	12 0 0	4½	6·75
7/16	2⅝	1·575	·293	9 0 21	3½	5·25

* The tensile strain is applied to each of the eight lengths separately, and not to the whole length of 100 fathoms at one time; and each length is to be provided with a shackle and shackle bolt, to be tested as part of the chain.

ANCHORS.

Scale of Proofs showing the Tensile Strain to which Anchors are subjected before being received for the use of her Majesty's Naval Service.

Test of anchors in tons proportioned to their weight in cwts.

Weight.	Test.	Weight.	Test.	Weight.	Test.	Weight.	Test.
Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.
100	67 1/2	75	56 1/4	50	42 3/8	25	24 3/4
99	67 3/8	74	56 1/8	49	41 1/2	24	23 7/8
98	66 1/4	73	55 1/2	48	41 1/8	23	23 1/4
97	66 1/8	72	54 3/8	47	40 1/4	22	22 5/8
96	65 3/4	71	54 1/4	46	39 3/8	21	21 5/8
95	65 5/8	70	53 1/8	45	39 1/8	20	20 1/4
94	65	69	53 1/2	44	38 1/8	19	19 3/4
93	64 1/2	68	52 3/8	43	37 1/8	18	19
92	64	67	52 1/8	42	37 1/8	17	18 1/4
91	63 5/8	66	51 1/2	41	36 1/8	16	17 3/8
90	63 1/4	65	51	40	35 1/2	15	16 1/4
89	62 3/4	64	50 1/2	39	35 1/8	14	15 1/8
88	62 1/8	63	50	38	34 1/8	13	14 1/2
87	61 1/2	62	49 1/2	37	33 1/2	12	13 1/8
86	61 1/2	61	48 1/2	36	33 1/8	11	12 1/8
85	61	60	48 1/8	35	32 1/8	10	12
84	60 1/2	59	47 1/2	34	31 1/8	9	11 1/8
83	60	58	47 1/8	33	30 1/4	8	10 1/8
82	59 1/2	57	46 1/8	32	30 1/8	7	9 1/4
81	59	56	46	31	29 1/8	6	8 1/4
80	58 1/2	55	45 1/8	30	28 1/8	5	7 1/8
79	58 1/4	54	44 1/4	29	27 1/4	4	6 1/8
78	57 1/2	53	44 1/8	28	27 1/8	3	5 1/4
77	57 1/4	52	43 1/8	27	26 1/8	2	4 1/8
76	56 1/4	51	43	26	25 1/8	1	3 1/8

NOTE.—The strain is applied on the arm, or on the palm, at a spot which, measured from the extremity of the bill, is one-third of the distance between it and the centre of the crown.

ARMOUR PLATE.

Table of the Weight of a Square Foot of Armour Plate from Half to Eighteen Inches Thick.

Inches.	lbs.	Inches.	lbs.	Inches.	lbs.
½	20	6½	260	12½	500
1	40	7	280	13	520
1½	60	7½	300	13½	540
2	80	8	320	14	560
2½	100	8½	340	14½	580
3	120	9	360	15	600
3½	140	9½	380	15½	620
4	160	10	400	16	640
4½	180	10½	420	16½	660
5	200	11	440	17	680
5½	220	11½	460	17½	700
6	240	12	480	18	720

NOTE.—A ship of the *Prince Consort* class has about 11,000 square feet of armour plating 4½ inches thick. We see by the above table that a square foot 4½ inches thick = 180 lbs.

Then $\frac{11{,}000 \times 180}{2240}$ = about 883 tons + 26 tons (bolts and nuts for securing armour), = 909 tons total weight on ship.

PAINTING SHIP.

WHITE Lead is the principal ingredient in all ordinary colours used in painting, the *quality* is therefore of the greatest importance; it is most difficult to get it free of adulteration. The cheap kinds are adulterated by "byrates," which renders it of a less compact body, and causes it to be much more easily acted upon by the atmosphere. White lead improves by keeping. In mixing, the oil and turpentine should be thoroughly incorporated with the white lead. If patent dryers are used, the proportion is about half an ounce to a pound of colour.

Zinc White is more durable than white lead; it is extremely pure, but possesses little body.

Vegetable Black.—This is the cheapest and best black for all ordinary work. In a dry state it resembles soot, and being free from grit does not require grinding. It should be mixed with boiled oil.

Vermilion in a state of powder may be tested by placing a dust of it on a piece of clean white paper, and crushing it with the thumb-nail. If pure, it will not change its colour by any amount of rubbing; but if adulterated, it will become a deep chrome yellow, or assume the appearance of red lead, with which article it is mixed in order to cheapen it. This accounts for the unstable quality of the inferior kinds of vermilion. When using vermilion, if necessary to give two coats, *both* should be of the best quality.

Blue.—The most serviceable blue for the painter is French ultramarine. It is a permanent, kindly working colour, and affords a variety of clear tints when mixed with white. It is a brilliant blue, and preserves its purity when reduced in tone by the addition of white.

It may be deepened by Prussian blue or indigo, or by a trifling addition of vegetable black.

Green, like black, should be mixed with boiled oil, or boiled oil and varnish; and not with linseed oil and turpentine.

The allowance of paint for men-of-war is based on the calculation that all weather work outside and inside has one coat every four months; and between decks one coat every twelve months. This is considered to give enough paint for boats, etc.

One pound of stiff white paint with the necessary thinnings is supposed to cover about five and a half square yards of smooth surface. The same quantity of black about eight square yards.

Proportions for Mixing Paint Materials.

Proportions for	Black.	White.	Raw Linseed Oil.	Boiled Linseed Oil.	Turpentine.	Litharge.
	lbs.	lbs.	Gals.	Gals.	Gals.	Gals.
Outside	112		$2\frac{1}{2}$	$2\frac{1}{2}$	$\frac{1}{4}$	6
,, ...		112	$3\frac{1}{4}$		$\frac{1}{4}$	4
Upper deck—						
Weather work ..		112	$2\frac{1}{8}$		$1\frac{1}{8}$	4
Between decks—						
Cabins, boats, etc. ..		112	$1\frac{3}{8}$		$1\frac{3}{8}$	4

Litharge should always be ground in oil, and on no account should it be put in paint in a dry state. It also should not be mixed with paint until it is about to be used.

Quantity of Paint required to give Masts, Yards, etc., of Various Ships in the Navy One Coat.

Material.	Ironclad.	Corvette.	Sloop.	Gun Vessel.	Gun-boat.
	Cwt. qrs. lbs.	Qrs. lbs.	Qrs. lbs.	Qrs. lbs.	Qrs. lbs.
White lead ..	1 2 0	3 14	2 14	1 14	1 14
Yellow	2 14	2 0	1 21	1 0	1 0
Venetian red ..	2	$1\frac{1}{2}$	$1\frac{1}{4}$	1	1
Litharge	9	6	5	3	3
Linseed oil ..	9 Gals.	6 Gals.	5 Gals.	3 Gals.	3 Gals.

Mixing Colours.

Cream Colour.—Chrome yellow, the best Venetian red, and white lead.

Fawn Colour.—Burnt sienna, ground very fine, mixed with white lead.

Drab.—Raw or burnt umber and white lead, with a little Venetian red.

Purple.—White lead, Prussian blue, and vermilion.

Violet.—White lead, French ultramarine, vermilion, and a small portion of black.

French Gray.—White lead and Prussian blue, tinged with vermilion.

Salmon Colour.—White lead, tinged with the best Venetian red.

Imitation of Gold.—Mix white lead, chrome yellow, and burnt sienna, until the proper shade is obtained.

Gilding.

Books of gold leaf contain twenty-five leaves. Gilders estimate their work by the number of "hundreds" it will take (meaning one hundred leaves), instead of the number of books.

Gold leaf should fall freely from the book on the leaves being opened, without any particles sticking to the paper.

The simplest way to use gold leaf is as follows:—Procure a clean sheet of silver or tissue paper, of not too great a density, and rub it over lightly on one side only with a piece of white wax; beeswax or wax candle will do. The paper should be placed on something flat, so that the wax is spread evenly.

After waxing a sheet of paper it should be cut into squares a little larger than the leaves of the book of gold, which should be opened, and the waxed side of the tissue paper gently pressed on the gold leaf. On removing the paper the gold leaf will be found attached to it, and is ready for use. All that the gilder has to do, is to cut it into convenient strips, and pressing it on to the sized surface, the gold will readily leave the paper. The work should be finished by gently dabbing it with a pad of cotton wool.

Gilt work exposed to the weather lasts much longer if it receives a coat of clear varnish when finished.

Size.—Oil gold size gives the best results, but requires time—twelve hours or so—before it gets "*tacky*" enough. Japanner's gold size, on the other hand, dries very quickly, and is useful when pressed for time.

In estimating amount of gold leaf required for gilding ordinary grooved mouldings round boats, etc.—one leaf covers about nine inches.

USEFUL PRACTICAL RECIPES.

Paint for Tarpaulins.—Add twelve ounces of beeswax to one gallon of linseed oil; boil it two hours; prime the cloth with this mixture, and use it in place of boiled oil for mixing the paint.

Copper Colour Paint (a very good recipe).—Six parts of spruce ochre; one part of Venetian red; and one part of black.

Bronze Paint.—Chrome green, two pounds; ivory black, one ounce; chrome yellow, one ounce; good japan, one gill. Grind all together, and mix with linseed oil.

Removing Old Paint.—Nothing is so efficacious as heat, applied by a small brazier with a handle.

One part of pearl ash mixed with three parts of quick stone lime (slaking the lime in water and then adding pearl ash), laid over paint work, and allowed to stand fourteen or sixteen hours, will so soften it, that it can be easily scraped off.

To Kill Knots.—(1) One pint of vegetable naphtha, one teaspoonful of red lead, quarter of a pint of japanner's gold size, seven ounces of orange shellac. Add them together, set in a warm place to dissolve, and let the whole be frequently shaken. Coat the knots with it.

(2) Mix red or white lead powder in strong glue size, and apply it warm. Or, cover with lime for twenty-four hours, then coat with red lead and glue.

Putty.—Well dried and sifted whiting (112 lbs.), and two gallons linseed oil well mixed, left for three or four days, and then worked up again before using.

To 56 lbs. of whiting add three pounds of glue boiled in half a gallon of water. No more water should be used than is necessary to soak the whiting.

Jelly or parchment size may be used instead of glue. A little alum added has a good effect in hardening.

To make Size.—Parchment chippings make the best. Put them in an iron kettle and fill with water; let it stand twenty-four hours; then boil for five hours, occasionally taking off the scum. Strain through a coarse cloth. If the size is required to be kept any length of time, dissolve three or four ounces of alum in boiling water, and add to every bucketful. Then boil again till it becomes very strong, and strain a second time.

Boiled Oil for Quick Drying Purposes.—With two gallons of linseed oil mix two pounds of litharge and one pound of red lead. Keep it on the fire, allowing the heat to increase gently; boil for three hours; then remove it from the fire, and let it stand twenty-four hours; take off the scum which has formed on the top, and it will be ready for use.

Boiled Oil.—(1) To sixteen gallons of oil, when boiling, add one pound of red lead and one pound of powdered litharge. Time for boiling, six hours.

(2) Four and a half gallons of raw linseed oil, one pound of copperas, two pounds of litharge. Put the litharge and copperas in a cloth bag, and suspend in the middle of the kettle. Boil four hours and a half over a slow fire, then let it stand.

Baked Oil.—Into an iron pot put half-gallon of linseed oil, to which add half-pound of litharge; boil carefully; keep simmering for fourteen or fifteen hours, and if when a little cooled it will draw into a thread, the oil will be ready for use.

Black Varnish.—(1) Sandarac, four ounces; yellow resin, two ounces; lampblack, one ounce; spirits of wine, one pint.

(2) To asphaltum and spirits of turpentine, add a small portion of baked oil.

(3) To baked oil dissolved in spirits of turpentine, add Frankfort black.

Black Japan Varnish.—Bitumen, two ounces; lampblack, one ounce; Turkey umber, half an ounce; acetate of lead, half an ounce; Venice turpentine, half a pint; boiled oil, twelve ounces. Melt the turpentine and oil together, carefully stirring in the other ingredients previously powdered. Simmer all together for ten minutes.

Black Japan for Metal.—Burnt umber, four ounces; asphaltum, one ounce and a half; boiled oil, two quarts; mix by heat and then with turpentine.

Vermilion Varnish.—Baked oil dissolved in spirits of turpentine, with vermilion added.

Lac Varnish.—Five parts of lac, one of turpentine dissolved in five times its weight of alcohol; keep gently warm until fluid, then strain.

Spar Varnish.—Boiled oil and resin.

Varnish for Painting on Glass.—Take one ounce of clear resin; melt it in an iron vessel; when all is melted, let it cool a little, but not harden; then add turpentine, sufficient to keep it in a liquid state. When cold, use it with colours ground in oil.

White Varnish, for Range Tables, etc.—White resin and turpentine dissolved in a close bottle, placed in hot water on a stove.

Or—Canada balsam, one ounce; spirits of turpentine, two ounces; mix them together. Before varnishing, the work should be sized.

Varnish for Carved Work.—Wood naphtha, one quart; gum shellac, one pound; gum benzoin, two ounces; resin, three ounces.

French Polish.—Five ounces of naphtha; one ounce of shellac; one dram of myrrh; ten grains of isinglass; and six drams of olive oil.

Simple French Polish.—Methylated spirit, one quart: gum shellac, half pound.

French Polishing.—Pour a little linseed oil into one cup, and some polish into another; take a piece of woollen rag, and having rolled it up into a ball, saturate it with polish, and cover with a piece of linen drawn tightly over it. Apply one drop of oil and one drop of polish to the surface of the pad, and it is ready for use. The work having been thoroughly smoothed, the polishing is commenced with free, circular strokes, applied with very slight pressure, and taking care that every part receives an equal amount of polish. Finish off with a little spirits of wine applied on a clean rubber.

Spirits of Wine.—In buying spirits of wine the most simple test is to pour a small quantity into a cup, set it on fire, and dip a finger into it; if it burns out quickly it is good; but if it is long in burning, and leaves any dampness remaining on the finger, it is mixed with inferior spirits.

Oil Polish.—Dissolve resin in turpentine to about the consistency of treacle; then, to one pint of resin and turpentine, so mixed, add two pints of linseed oil.

Staining.

Black Stain.—(1) Quarter pound logwood; six ounces green copperas; eight nut galls; half-gallon vinegar; and lay on warm.

(2) Boil half-pound logwood in two quarts of water, add one ounce pearl ash, half-ounce verdegris, and half-ounce copperas. Strain it off, put in half-pound rusty steel filings; and lay on warm.

(3) Boil half-pound logwood in two quarts of water, add one pint vinegar, half-pound rusty steel filings; and lay on warm.

(4) Place in a breaker two pounds of copperas, two pounds nut galls, eight pounds alum pounded up, eight pounds old iron, and twenty-five pints vinegar. When wanted for use boil as much as is required, and lay on hot. The longer it is kept the better it becomes.

Rosewood Stain.—Cover strips of logwood with water, boil it, add a very small piece of pearl ash (this must be used very cautiously), lay on hot, and then streak with tincture of steel.

To Dye Bright Red.—Take two pounds of red Brazil dust, and four gallons of water, put in veneers until well covered, boil for three hours, and let them cool; then throw in two ounces of alum, one ounce of nitric acid, and keep lukewarm until the mixture has struck through.

To Dye Yellow.—Take four pounds of the roots of barberry, reduced to sawdust, and four gallons of water; add quarter pound turmeric. Put in as many veneers as the liquor will cover; boil for three hours, often turning them. When cool, add two ounces of nitric acid to assist the dye in striking through.

To Colour Light Woods.—Curly veined birch and beech regularly brushed with aquafortis, and dried at the fire, look remarkably like mahogany.

Another method is to smear the surface with a strong solution of permanganate of potash. About five minutes will generally suffice. When the action is ended, the wood is carefully washed, dried, and afterwards oiled, and polished in the ordinary way.

Polish for Iron.

Black Gun Polish.—Four ounces resin, two ounces lampblack, three ounces beeswax, two ounces shellac, one quart linseed oil. Boil 50 minutes, then add a half-pint of turpentine. For bronzed guns omit the lampblack.

Black Polish for Iron.—Coal tar one pint, lampblack one ounce, hellebore half-ounce, spirits of turpentine quarter pint, beeswax one ounce. The beeswax and hellebore to be dissolved in the turpentine. Then add the lampblack and tar; mix, warm it well, and apply hot. Or, dissolve in turpentine, half-pound of beeswax, four ounces of hellebore, and four ounces of lampblack.

Lacquering.

This is done in two ways, called cold lacquering and hot lacquering. By the former a little lacquer is laid carefully and evenly over the work with a camel-hair varnish brush; it is then placed in an oven or hot stove for a minute or two to set the lacquer. By the second method the work is heated first, and the lacquer brushed quickly over it. The great difficulty is to know the exact degree of heat, and this knowledge cannot be attained except by experience.

To prepare Brass for Lacquering.—The surface of the work being cleaned as well as possible, place it in aquafortis and water, leave it there for some hours, and then put it into hot sawdust, and shake about until thoroughly dry and clean.

Brass Lacquer.—(1) Seed-lac, dragon's blood, annatto, and gamboge, of each four ounces; saffron, one ounce; spirits of wine, ten pints.

(2) Methylated spirits of wine, one gallon; seed-lac bruised, ten ounces; red sanders, half ounce; dissolve and strain.

Iron Lacquer.—Three pounds asphaltum, half-pound shellac, one gallon turpentine.

Miscellaneous.

Brown Bronze Paint for Copper Vessels.—Tincture of steel, four ounces; spirits of nitre, four ounces; essence of dendi, four ounces; blue vitriol, one ounce; water, half pint. Mix in a bottle and apply with a fine brush, the vessel being full of hot water. Varnish over the paint.

Marine Glue.—One part india-rubber, twelve parts mineral naphtha or coal tar; heat gently, mix, and add twenty parts of powdered shellac. Pour out on a slab to cool; when used, to be heated to about 250° Fahr.

Glue to Resist Moisture.—Glue which has been swelled by water dissolved in linseed oil.

Glue Cement to Resist Moisture.—One pound glue, one pound black resin, quarter pound red ochre, mixed with the least possible quantity of water.

Cement for Cloth or Leather.—Sixteen pounds of gutta-percha cut small, four pounds india-rubber, two pounds pitch, one pound shellac, two pounds linseed oil, melted together and well mixed.

Waterproofing for Boots.—Linseed oil one quart, beeswax six ounces, spirits of turpentine four ounces, Burgundy pitch one ounce. Melt wax and oil together and dissolve the pitch in the turpentine; pour both into a jar, and place it in a saucepan with water, boil and stir till well mixed. Being very inflammable, beware of fire getting near it.

To Waterproof Cloth.—Make after the following manner two separate solutions:—1st. Dissolve one pound of sugar of lead in one gallon of water. 2nd. Dissolve one pound of alum in one gallon of water. Dip the cloth first in the solution of lead, and, when nearly dry, dip it in the solution of alum, then dry it in the air or before the fire. This process may be used for coats after being made up.

Cement for Coating the Inside of Outer Bottoms of Iron Ships.—Roman cement, 338 parts; pitch, mineral, 325 parts; lime, white, 82 parts; resin, 13 parts; tar, mineral, 32 parts; total, 790 parts.

The mineral pitch is to be boiled for four hours, the cement, lime, and resin being added in small quantities; care being taken that they are well mixed in, that the resin is well powdered, and the lime free from lumps; after which the mineral tar is added.

Before using, the bottom should be well scraped and cleaned, and then well payed with a thin coat of boiled mineral tar, put on while hot.

Mortar.—One part of lime, to three, or three and a half, of sharp river sand.

Coarse Mortar.—One part of lime, to four of coarse gravelly sand.

Concrete.—One part of lime, to four of gravel, and two of sand.

Dubbing.—Two pounds of black resin, one pound of tallow, one gallon train oil.

Distemper Colours.

White.—Whiting ½ cwt., glue 6 lbs.

Yellow, for Funnels.—Whiting ½ cwt., yellow ochre ¾ cwt., glue 6 lbs. The glue is made into size and added hot to the whiting, etc., mixed with water in sufficient quantity to give it the proper consistency for use.

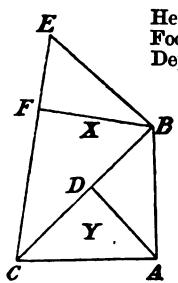
Colours for Working Drawings.

Material.	Representative Colours.
Brass	Gamboge or chrome yellow.
Brickwork	Carmine.
Cast iron	Neutral tint or gray.
Clay or earth	Burnt umber.
Concrete	Sepia with dark markings.
Copper	Carmine or lake.
Granite	Pale Indian ink.
Lead	Indian ink, tinged with Prussian blue.
Steel	Pale blue, tinged with lake.
Water	Cobalt.
Woods	Burnt sienna, or raw sienna for light wood
Wrought iron	Prussian blue.

To Find the Number of Square Yards in Sails.

Head × Depth + Depth × ½ difference of Head and Foot.

EXAMPLE.



Head = 43½ cloths = 29 yards
Foot = 46 cloths = 30½ yards
Depth = 12⅔ yards.

29 × 12·66 = 367·14
12·66 × ·75 = 9·47

376·61 square yards.

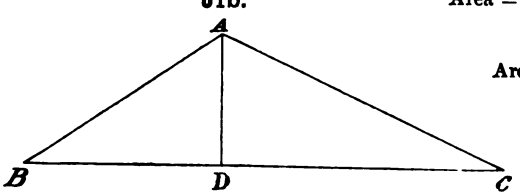
Trysail.

$$\frac{EC \times BF}{2} = X.$$

$$\frac{BC \times AD}{2} = Y.$$

Area = X + Y.

Jib.



$$\text{Area} = \frac{BC \times AD}{2}$$

INFORMATION AND INSTRUCTIONS FOR DIVERS.

Siebe and Gorman's Patent Apparatus.

THE apparatus consists of a patent double-acting air-pump for supplying one or two divers with air; two men can work under a ship's bottom independent of each other from the same pump. By an ingenious arrangement with a lever, the supply of air can be thrown into one outlet from both cylinders, so that the one diver can work to a depth of 160 feet or 26 fathoms. When two divers work from the pump they can with safety descend to 90 feet or 15 fathoms. The pressure gauges denote the depth at which the divers are working.

The helmet is made of copper tinned, with a segmental neck ring to unscrew the head-piece from the collar by one-eighth of a turn, lock-pin to prevent it unscrewing, inlet and outlet valve, inflating arrangement so that the diver can rise to the surface, and regulating cock, under control of diver to regulate his supply of air. Four lenses; front, two side, and top glass; the india-rubber dress is fastened to the helmet by means of brass bands in segments, two front, two back; with screws and wing nuts. A spanner is provided to fit the nuts for screwing tight the bands.

India-rubber dress made of tanned twill with vulcanized collar and cuffs, the collar forming a water-tight joint on helmet collar, cuffs kept tight by flexible rings. Boots have lead soles, 16 lbs. weight each. Back and front lead weights fitted to helmet with clips, weight of each 40 lbs. There is a shackle used for protecting the stomach from pressure, when diving in deep water. Leather belt with metal pipe-holder, knife in water-tight brass case, used for the diver to clear away rope. The air-pipe is made of five-ply india-rubber and canvas, with spiral wire imbedded with gun-metal joints lashed in each, of 45 ft. and 30 ft. lengths; the pipe stands pressure to 100 lbs. square inch.

Care must be taken in dressing the diver, but when once under water the apparatus is self-acting, so that the man has only to think of the work he is going to perform. It is always advisable in a ship's crew to have the same men to attend the diver, that is, the signal man and men to work the pump; the ship's diver should be, according to Admiralty regulations, down at least once a month.

Divers at the depth of 32 feet under the water have upon the surface of their whole body a more than ordinary pressure of 20,000 lbs. weight, yet when we consider the uniformity of that pressure, and its equability, which causes no dislocation of the parts, all the external being equally affected with it, and being internally supported by the air and other elastic fluids, which constantly endeavour the more to expand themselves as they are compressed; if we also consider the firm texture of the membranes and other solid parts of the human body, and the incredible force they are able to bear, as has been demonstrated by experiments; we shall not much wonder that divers complain of no sensible pain, though they be pressed with so great a weight of water, besides the ordinary pressure of the air which our bodies are continually exposed to, and which is equal to a depth of 32 feet of water, or 20,000 lbs., so that the whole pressure to which a diver is exposed at 32 feet of water is 40,000 lbs., and in ratio as he descends.

The following Table represents the Pressure in lbs. on the Square Inch at a given Depth of Water.

20 feet . . .	8½ lbs.	90 feet . . .	39 lbs.
30 „ . . .	12¾ „	100 „ . . .	43½ „
40 „ . . .	17¼ „	110 „ . . .	47¾ „
50 „ . . .	21¾ „	120 „ . . .	52¼ „
60 „ . . .	26¼ „	130 „ . . .	56½ „
70 „ . . .	30½ „	140 „ . . .	60¾ „
80 „ . . .	34¾ „	150 „ . . .	65¼ „

As to the effect of compressed air upon the lungs, and the general construction of the human body, scientific men vary, and as we have no data from which we could form actual conclusions, we can only arrive at a result by the effects produced upon divers that have come under our notice. The first time a man descends under water he is ordinarily suffering from inherent nervousness, occasioned by the fact of undertaking a thing that has hitherto been unknown to him, consequently there is an increased pulsation and peculiar gasping for breath; and it happens in some cases to be so strong that it would be unadvisable whilst in that condition to allow him to descend, but rather, by making him acquainted with the working of the apparatus, and the example of teaching others to descend, it will gradually remove the nervous weakness which attends many constitutions. When the nervousness is overcome it would be advisable that he should descend slowly, swallowing his saliva, and not demanding too much air, resting at times to recover his equilibrium; and if the pressure should cause too great

a pain in the head, by gently ascending a few feet it will gradually remove it, and the descent can be continued.

Remarking the effects of compressed air on the lungs, Mr. Brunel, when inspecting an accident over the Thames Tunnel, the bell not being able to enter the hole, took a rope from one of the attendants and plunged into it, remaining about two minutes, much above man's natural powers. The compressed air in the bell being about 32 lbs. on the square inch, it is reasonable to suppose that the lungs act as air-sponges, and were saturated with this condensed vital element as he left the bell. Would it not, therefore, take more time than in ordinary circumstances to exhaust this double provision of breath?

The rule as to coming up depends very much upon the constitution of the diver. A man at all sanguineous should ascend rather slowly; the brain being suddenly relieved from the pressure causes a sudden rush of blood to the head, and it may cause unpleasant and serious consequences. We should advise a diver to ascend at a rate of not more than two feet every second, that is, for a strong constituted man. Nor should a diver, for at least two hours before commencing operations, take any food. If any kind of refreshments be required, a biscuit, with a small quantity of drink, or anything that will not excite the digestion, may be taken during the operations.

Instructions for the Dressing of Diver and the Management of Apparatus.

Previous to the diver being dressed, place the fly-wheel on crank shaft, and fix the handles at right angles, oil the pistons with olive or neatsfoot oil, and also the bearings and other working parts; let the pump be worked for a few minutes; also pour some water into the cistern to keep the cylinders cool, to prevent the air being heated and thus becoming rarefied. The piping should be laid on the deck or place from whence the descent is to be made, in a serpentine form, so that the pipe does not kink. Remove the nut on air-nozzle, and connect the air pipe. The attendant should place his finger over the joint at the end of air-pipe, and let the pump work so that he can test the working of the air-pump's valves, and blow out any dust that may be in the pipes. If the water in the cistern becomes heated it should be renewed.

Put on the Guernsey frock, a pair of drawers and stockings according to the temperature of the water; place helmet cushion on shoulders, and tie the outside collar piece round neck, and round each wrist place one or more

vulcanized india-rubber rings. A piece of linen should be placed between the flesh and dress; the cuff expanders should be used, so that the diver can pass his hand; then put on helmet collar, place the vulcanized collar over the screws, put on the metal plates, and screw the dress between moderately tight with the wing nuts; be particular that the four nuts at joints are screwed up at the last. To keep the dress from chafing put on large overall stockings and canvas overall dress, then the boots with lead soles, and the leather belt with pipe-holder and knife. The attendant should blow through the outlet valve of the helmet; he can do so by placing his head in the interior, and placing his mouth to the hole where the air escapes. Blow strongly; if in proper working order the valve will vibrate.

Connect air-pipe to inlet valve; previous to doing so pass it through the pipe-holder on belt, leading it under the left arm of diver. The signal line to be fastened round the body, and to pass up the front of the right shoulder. The head-piece (without the front glass) can now be screwed on, which is done by one-eighth of a turn. Next attach the lead weights, one behind and one before; the lines of the back weight pass over the loops on head-piece; the small line should be fastened to the lower corner of weights and round the waist with a slip-knot in front. The diver now being dressed, the air-pump must be set in motion; when all is ready for the diver to descend, screw in the front glass.

Life Line.—One pull	. . .	All right.
„ Two pulls	. . .	According to diver's instructions.
„ Three pulls	. .	„ „ „
„ Four pulls	. .	Coming up.
Air-Pipe.—One pull	. . .	Sufficient air.
„ Two pulls	. . .	More air (pump faster).
„ Three pulls	. .	According to diver's instructions.
„ Four pulls	. .	Haul up diver.

To communicate with the diver when underneath the water by word of mouth, experiments have been made with very satisfactory results, and are now in operation.

Divers' ladders are generally made of inch rope, with ash rounds 22 inches long, and weighted at the end. Some divers have the ladder only 20 feet long; to the last round a rope with a weight attached, which rests on the bottom; by that means they descend.

All now being ready, let the diver descend, and when he reaches the bottom, before he leaves the ladder, he must make fast a small leading line to the ladder. The line should be coiled in the hand with a loop round the

wrist, and as he leaves the ladder he lets the rope gradually uncoil, so that if he is any distance off he can find his way back to the ladder if he wants to ascend; but if by accident he loses the line and is unable to find the ladder, he should make the signal to haul him up. In extreme cases the weights may be thrown off, that is, if he finds himself in any danger and wishes to rise directly to the surface of the water; but this expedient should be seldom resorted to, as the signal for hauling up can always be given, and with presence of mind many difficulties can be overcome, when hurry and excitement may cause the loss of the diver's life.

The diver should seldom go forward; he must generally go backwards; and if he meets with anything he must turn round and feel, particularly in the dark; but be careful to return the same way, otherwise he crosses the pipe and line; this precaution is very necessary. If entangled in the rigging make use of the knife at side to clear himself away.

As some men require more weight to sink them than others, we would recommend them to make a shot-belt to buckle round the waist; it may be made any weight the diver may think necessary.

On the deck or place from whence the diver descends, two careful, confidential persons must attend the signal line and air-pipe; they must attend them with the greatest vigilance, and keep them always moderately tight. If they should feel any irregular jerks which may be occasioned by falls or otherwise, they must haul him up immediately. The attendants on deck must from time to time give the signal that all is right, and if the diver does not return the signal he must be immediately hauled up. Be particular that no conversation whatever is held with the attendants of the diver when below, or it may take off their attention from the signal or any circumstance that may occur.

If the plungers of the air-pump or the other motions get slack, they must be screwed up with the spanners sent for that purpose, when the plungers will swell out a little; great care to be taken that they are put in the same way as they are taken out, and all other parts of engine put together according to the marks. Always use olive oil for the air-pumps; if not to be got, use well-cleaned neatsfoot oil. When done working, and the engine is to be put by some time or lifted about, unscrew the plug at the lower edge of the back of the box and draw out the water, to prevent it washing over into the box or cylinders, or splashing the engine, or corroding the cistern if left standing. If the air-pump has been left standing by for any length of time, pour some warm water into the cistern, as it will warm the cylinders and soften the oil round the pistons, and the pump will work much easier.

To examine piston valves, withdraw piston from cylinder. When the valve can be unscrewed, to examine cylinder bottom valves, lean the chest back and unscrew iron plate on bottom of chest, and then unscrew the valve bonnets; this arrangement avoids the trouble of removing engine from chest.

Be careful that the leather washers are between the gun-metal joints, so that the air may not escape; also that the joints are screwed together moderately tight.

Should the waterproof dress, from constant use or accident, get leaky, it is easily repaired by laying two or three coats of varnish on each side of the seam, rubbing it with the finger as much as possible into the perforations made by the needle, allowing each coat to dry before the next is laid on; the sides of the seam may then be laid down, and two or three coats applied in the same manner to the channel of the seam, when the prepared strapping (which should have an extra coat laid on and dried) may be immediately applied, and well pressed down with the hand. Superfluous varnish may be removed with a piece of india-rubber, but it is better to lay it on the proper width, so as not to require cleaning off, as too much friction sometimes does injury. Beginners should prove their seams by tapping them, when moistened externally by water.

India-rubber diving dresses should never be packed away in a wet or damp state; they must be thoroughly dried both in and outside before so doing, otherwise they will mildew, and become so rotten as to be of very little service afterwards.

In case the diver urinates in the dress it should be turned inside out and washed with clean water, and then allowed to dry.

If the above directions are properly attended to, the diving dresses will last much longer.

The india-rubber pipes should also be thoroughly dried before packing away.

Should the dress and pipes be lying by for any length of time, and become hard, place them in a gentle heat, when they will become quite soft.

EXAMINATION OF ACTING SUB-LIEUTENANTS AT ROYAL NAVAL COLLEGE, GREENWICH.

I.—Details of subjects for Instruction and Examination of Acting Sub-Lieutenants at the Royal Naval College, Greenwich:—

	Full number of marks obtainable at Examination.
1. ALGEBRA.—Fundamental Operations; Fractions; Simple Equations; Involution and Evolution; Theory of Indices; Quadratic Surds; Quadratic Equations; Proportion; the Three Progressions; Elements of the Theory of Logarithms, including the use of Logarithmic Tables	125
2. GEOMETRY.—Up to the standard of the sixth Book of Euclid's Elements	125
3. TRIGONOMETRY.—Definitions and Fundamental Formulæ; Solution of Plane and Spherical Triangles . . .	125
4. MECHANICS.—Elements of Statics, Dynamics, and Hydrostatics	125
5. PHYSICS.—Mechanical Properties of Liquids and Gases, Optics, Heat, Magnetism and Electricity; including Construction and Use of the Barometer, Telescope, Microscope, Theodolite, Sextant, Dry and Wet Bulb Thermometers, Azimuth Compass	100
6. STEAM ENGINE.—Heat; Steam; Boilers; Engines; and Propellers	100
7. FRENCH.—Writing from Dictation; Pronunciation; Grammar; Translation from French to English, and from English to French	200
8. WINDS AND CURRENTS.—Prevailing Winds and Currents, their Geographical Limits, and their Changes at different Seasons; Cyclones, their characteristics, localities, seasons, rotation, and track; Relation of Barometric Pressure to prevailing Winds and Storms; Buys-Ballot's Law; Leading Theories of Winds and Currents, Rain and Rain Seasons .	100
9. PRACTICAL NAVIGATION.—The Sailings; Dead Reckoning; Mercator's Chart; Passage of Bright Stars over Meridian; Latitude by Meridian Altitudes, by Altitude of the Pole	

Star, by Altitudes near the Meridian, and by Double Altitudes; Longitude by Chronometer and by Lunar Distance; Error and Rate of Chronometer by Single Altitude, and by Equal Altitudes; Variation of Compass by Amplitude, by Altitude Azimuth, and by Time Azimuth; Time of High Water	200
10. NAUTICAL ASTRONOMY.—Definitions and Principles; Investigation of all Processes and Formulæ; Explanation of all Corrections used; Sumner's Method; Problems .	200
11. NAUTICAL SURVEYING.—Use of Charts; Rating of Chronometers; Determination of Meridian Distance; Selection and Measurement of a Base Line; Determination of Latitude, Longitude, and True Bearing; Triangulation; Levelling; Soundings; Fixing Positions; Tide Gauge; Establishment of the Port	100
12. INSTRUMENTS.—Construction and Use of Marine Barometer, Sextant, Artificial Horizon, Azimuth Compass, Theodolite and Level	40
13. OBSERVATIONS.—Of the Sun, for determining Latitude; Error of Chronometer and Variation of Compass . .	60
	1600

II.—The minimum number of marks required to be obtained is as follows, viz.:—

For a 1st Class Certificate . .	1300
„ 2nd „ „ . .	1050
„ 3rd „ „ . .	800

III.—With a view to encourage Officers to acquire a thorough knowledge of professional and other useful subjects, a Lieutenant's Commission, dated from the day of attaining six months' Seniority as Sub-Lieutenant, will be given to any Sub-Lieutenant who obtains First Class Certificates in all subjects, *i.e.* Seamanship, Navigation, Torpedo, Gunnery, Pilotage, and not less than 1380 marks in the College Examination. He must also be recommended by the President of the Royal Naval College, and must possess certificates of good conduct and zeal in the performance of his duties for the whole period of his service.

IV.—A prize of books or instruments to the value of £10 will be bestowed on those who obtain First Class Certificates in all subjects.

Beaufort Prize.

V.—Candidates for the Beaufort Testimonial should signify their intention of competing to the President of the College one month before the time of their examination; more searching questions will be set in all subjects.

The Goodenough Gold Medal is awarded annually to the Acting Sub-Lieutenant who, among those who have taken a First Class in Seamanship in passing for the rank of Lieutenant, passes the best examination of his year in Gunnery.

VI.—A List of the Text Books used at the College is subjoined for the information of the above class of Officers.

HAMBLIN SMITH .	Algebra (Rivington).
" " .	Plane Trigonometry (Rivington).
" " .	Elementary Statics (Rivington).
" " .	Elementary Hydrostatics (Rivington).
MAGNUS . . .	Lessons on Elementary Mechanics (Longmans, Green & Co.).
TODHUNTER . .	Spherical Trigonometry (Macmillan & Co.).
" . . .	Elements of Euclid. "
" . . .	Mechanics. "
GANOT . . . *or* BALFOUR STEWART .	Natural Philosophy (Longmans, Green & Co.). / Lessons in Elementary Physics (Macmillan & Co.).
LAUGHTON . .	Practical and Theoretical Nautical Surveying (Longmans, Green & Co.).
" . .	Physical Geography in its Relation to the Prevailing Winds and Currents (J. D. Potter, 31, Poultry).
WHARTON . .	Hydrographic Surveying (John Murray).
ROBINSON . .	Marine Surveying (Macmillan & Co.).
JEANS . . . *or* RAPER . . .	Nautical Astronomy and Navigation (Longmans, Green & Co.) / Practice of Navigation, and Nautical Astronomy (J. D. Potter, 31, Poultry).
GODFREY . .	Treatise on Astronomy (Macmillan & Co.).
SENNETT . .	Marine Steam Engine (Longmans, Green & Co.).
YEO . . .	Section on Steam in New Edition of Bedford's *Sailor's Pocket Book* * (Griffin & Co.).

* Students will also find in the *Sailor's Pocket Book*, 4th edition, information that will be useful to them in subjects Nos. 8 to 13 of the examination.

PILOTAGE EXAMINATION.

Regulations in regard to Acting Sub-Lieutenants passing in Pilotage.

Acting Sub-Lieutenants are required to pass an examination in Pilotage, and after completing the examination for Lieutenant in Gunnery are allowed a period of two months for instruction in Pilotage. They are then required to pass the Pilotage examination in the Hydrographic Office, Whitehall.

The Examination of Lieutenants and Sub-Lieutenants for Navigating duties at the Hydrographical Department of the Admiralty, embraces the following subjects*:—

A FEW EXAMPLES OF THE QUESTIONS THAT MAY BE ASKED, ARE APPENDED.

Section I.—On General Pilotage and its Duties, especially in reference to those Stations on which the Officer may have served, together with a knowledge of the most desirable routes to be adopted in making passages at different seasons.†

Pilotage Duties.

What is that simple instrument whose constant use should be considered by the sailor and pilot, as indispensable to safe navigation?

Precautions to be adopted in pilot water;—when approaching the land in anchoring;—and duties when at single anchor or moored?

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* *See* Admiralty Circular, 11 N., April, 1882.

† *See Admiralty Pilots, Sailor's Pocket Book*, 4th edition, Sections III. and IV.; and Track Charts, Ocean Sailing Directions, and Distance Tables in the *Sailor's Hand Book*. G and Co., Portsmouth.

What lights are required to be exhibited when under steam?

What are the fog signals for a steam vessel under way, and a sailing vessel under way?

What is the "Rule of the Road at Sea" when two steam vessels are meeting or crossing, so as to involve the risk of collision?

Give an example when, seeing certain lights at night from a ship, the helm should be put to starboard.

Are you acquainted with the system of buoyage in use by the Trinity House of London for buoying channels? *

What lights are shown by vessels engaged in laying or picking up telegraph cables?

Home Stations.

In leaving the English Channel for the southward, would it be advisable to steer well to the westward? And why?

In approaching Cape Roca from the northward, would you expect a current with the wind from that quarter?

Have you any idea of the strength of the tides in the Tagus?

What dangers are there at the entrance to Cadiz?

In case of extreme necessity, with a westerly gale, bound southward, and unable to weather Cape Finisterre, what ports are available to leeward?

Mediterranean Station.

Can you give any particulars of the currents in the Strait of Gibraltar, and of the tides on either shore?

What precaution is necessary in working round Europa Point with westerly winds?

Where is the greatest rise and fall of the tide in the Mediterranean?

What danger lies between the coast of Sicily and Pantellaria; and what is the least water on it?

What are the principal anchorages on the coast of Syria?

Are there any good harbours on this coast?

* *See Sailor's Pocket Book*, page 169.

North America and West India Station.

Where may ice be met with in the North Atlantic?

During what months?

During what months is the Gulf of St. Lawrence closed by ice?

Why is Sable Island a formidable danger?

Has your attention been called to the fact of the great decrease in the variation of the compass on approaching the coast of Nova Scotia from the eastward?

Have you considered which are the best routes from England to Halifax, in summer and winter?

What is the greatest rise and fall of tide in the Bay of Fundy?

South East Coast of America.

Bound from the English Channel to any port on the S.E. coast of America between what meridians would you cross the Equator; and why?

Describe the land about Rio de Janeiro.

During what months do the pamperos prevail in the River Plate?

In making the passage from Rio de Janeiro to Magellan Strait, or to round Cape Horn, what general course would you adopt, and why?

Is there any great change in the rise and fall of the tide in Magellan Strait between Cape Virgins and Sandy Point?

Why is the consideration of the tides an important element in the navigation of the Strait of Magellan?

West Coast of Africa.

Name the dangers at the entrance of Sierra Leone.

If bound from the Bight of Biafra or Benin to England, or to Sierra Leone, or the Gambia, what route would you pursue?

During what months may rollers be expected on this coast, and at St Helena?

During what months do the N.W. winds prevail in Table Bay?

East Indies.

Leaving the Cape of Good Hope for the Bay of Bengal, so as to have the Indian S.W. Monsoon (April to October), how far south would you steer; and on what meridian would you haul to the northward?

What course should be followed by a steam vessel of small power in making the passage from Point de Galle to Aden, during the months of June and July?

What are the tides of the coasts of India peculiarly affected by?

To what extent does this diurnal inequality affect the times and height of the tides?

Australia and New Zealand.

In proceeding from the Cape of Good Hope to the south coast of Australia, on what parallel would you run?

Leaving Sydney, what route would you take to the Fiji Islands?

What is the general appearance of the Tonga or Friendly group of islands? And name the principal harbours in this group?

Having passed Tiri Tiri, pilot a ship into Auckland Harbour and anchor. Rangitoto being a useful mark, describe its appearance.

If bound from Melbourne or Sydney to ports in China or Japan, what route would you adopt through the Pacific Ocean?

Have the islands on these routes been surveyed?

China Station.

Between what months does the S.W. Monsoon prevail in the China Sea, and when is it the strongest and least liable to change?

When does the N.E. Monsoon begin?

How would you make the passage from Singapore to Hong-Kong during the N.E. Monsoon?

Pilot a ship of heavy draught into Hong-Kong through the west channel?

In a vessel of moderate steam power, how would you make the passage from Hong-Kong to the northern ports of China in the N.E. Monsoon?

Pacific Station.

In entering the Pacific Ocean from the Strait of Magellan, bound to the northward, and finding a southerly wind, what course would you steer?

Name the anchorages in the Strait of Magellan convenient for a ship in her passage through.

If using the Smyth and Messier channels, name the convenient anchorages.

Is there any peculiarity in the current off the coast of Chili that should make the navigator particularly cautious?

What are the dangers in the Bay of Panama, if passing northward of the Pearl Islands?

Bound from Panama to Vancouver's Island, what route would you follow?

What are the dangers of the entrance to the harbour of San Francisco?

What dangers are there off Cape Flattery?

Section II.—On the Pilotage of the English Channel; to include a knowledge of the character of the lights, beacons, landmarks, tides, etc., and the officer's ability to conduct a ship into, or out of, the principal ports, harbours, and anchorages, between the Scilly Isles and the North Foreland.*

Entering the Channel and to Plymouth.

In running up Channel is a continuous line of soundings necessary to safe navigation, and why?

Name an invention that much facilitates the operation of deep-sea sounding?

What lights does a light vessel show when driven from her station?

What light does a light vessel marking a wreck show?

Describe an Occulting light, and an Intermittent light.

Which side of the English Channel is preferable for navigation?

In thick weather, how would you know which side of the Channel you were on?

Within what depth would it be imprudent to stand towards the Scilly Isles in thick weather?

* *See* King's *Pilot's Handbook for the English Channel*, the latest edition; and the *Sailor's Pocket Book*, 4th edition, article "Tides."

Entering the Channel after a succession of westerly winds, and without astronomical observations to verify position, what would be the probable effect on the reckoning?

Previous to entering the Channel after a long absence, can you suggest any precautionary measures by which the deviation of the compass on the Channel course may be ascertained?

What lights are shown from the Scilly Islands?

Would it be prudent in a stranger, unless compelled by necessity, to attempt any of the harbours in the Scilly Islands without the aid of a pilot?

Describe the Wolf Rock and its situation.

How far do the dangers off the Lizard extend?

How far do the Manacle Rocks extend, how are they marked, and what are the clearing marks by day and night?

How is Eddystone lighthouse coloured, and what is the nature of the light exhibited?

Approaches to Plymouth Sound.

What are the features by which Plymouth may be readily known?

What are the dangers outside the breakwater, and how are these dangers marked?

Describe the buoys in the Eastern Channel, and what these buoys mark.

What mark leads to the southward of all these dangers outside the breakwater?

At night, having the Eddystone light in sight, how would you proceed into Plymouth Sound?

Start Point to Portland.

Are there any natural features by which Start Point may be recognized?

What is the nature of the light exhibited from Start Point?

What are the peculiarities in the stream of tide off the Start?

In beating up Channel at night or in thick weather, between the Eddystone and Start, what depth of water would you stand in to?

What danger is to be avoided when approaching Portland?

When would it be prudent to sail between the Bill of Portland and Shambles, and why not at other times?

What depth of water would you stand into between the Start and Portland at night or during thick weather?

Describe light on the Casquets.

Approaches to Needles and Spithead.

What are the principal dangers at the entrance of the Needles Channel?

What is the effect of flood and ebb in connection with the Shingles?

Which is the dangerous side of the Needles Channel on flood and on ebb?

Is any precaution necessary when approaching the land in thick weather between the Needles and St. Catherine's Point?

If beating up Channel at night or in foggy weather, into what depth would you stand between Portland and Dunnose?

What is the least water on Princessa Shoal, and how is it marked?

What is the mark to clear the south side of the Princessa?

What water is there on the Nab Rock, and how is it marked?

Describe the Nab light and the position of the light-vessel.

In a ship of heavy draught, at low water springs, with bad weather and a heavy sea, by which route would you proceed to Spithead?

What would be the least water in this route?

When does the eastern stream begin to run at Spithead?

How long does it continue to run in that direction?

Spithead to Dungeness.

How far off Selsea Bill do the shoals known as the Owers extend, and in what direction?

Describe the position of the Owers light-vessel, and the nature of the light exhibited.

What are the remarkable features of Beachy Head?

Is the lighthouse on the most prominent part of the headland?

Into what depth of water would you stand in thick weather between the Owers and Beachy Head?

In thick weather how near would you approach the shore between the *Royal Sovereign* Shoals and Dungeness?

Downs.

What lights are exhibited from the South Foreland, and on what bearing are they in line?

Describe the lights exhibited from the South Sand Head, Gull Stream, and Goodwin light-vessels.

Describe the buoys marking the channel through the Downs.

Is any precaution necessary in anticipation of Slipping from the Downs? State how you would proceed from off the South Foreland through the Downs to the North Sea.

Tides in English Channel.*

Give a general description of the direction of the tidal streams east and west of Dover Straits.

When it is high water in Plymouth Sound, in what direction is the stream running off the Eddystone?

Section III.—On the modes of constructing Charts, and the practical use of them; the laying off a Ship's Position readily from astronomical observations, and by bearings and angles.†

Why is a chart on Mercator's projections so convenient for purposes of navigation?

In what proportion must the degree of latitude on a Mercator's chart be made to the degrees of longitude in order that they may be relatively equal to those on the sphere?

Is a straight line drawn from one place to another on a Mercator's chart the shortest distance between them? If not, what line would represent the shortest distance?

In what cases would the arc of a great circle have the greatest effect in shortening the distance?

Given the bearing of, and distance from, a lighthouse; place the position on the chart.

On the chart,—Given two bearings of a lighthouse and a course and distance run between them; mark the position at the time of both bearings.

* *See* King's *Pilot's Handbook*; Admiralty Tide Tables; and the *Sailor's Pocket Book*, 4th edition, pages 205 to 210.

† *See* Rapers' *Navigation*; Hull's *Practical Nautical Surveying*; and the Sailor's Pocket *Book*, 4th edition, Section V.

On the chart,—Given two angles between three points; mark the position of the ship on the chart.

To survey a harbour or bay of which there is no chart, how would you proceed, with the ordinary instruments on board?

How would you proceed to take soundings, and how would you fix the position of the soundings?

What modes would you propose to ascertain the reduction to be applied to each sounding in order to reduce them to low water?

Supposing you discovered a danger out of sight of land, what steps would you take to examine the same and also to determine its position?

State in detail how to rate a chronometer.

Section IV.—On the System of Winds and Currents which prevail over the different Oceans, to include a knowledge of the uses of the barometer and thermometer as applied to Navigation. On the regions of exceptional storms, hurricanes, or cyclones, together with the most judicious methods to be adopted for avoiding their greatest violence.*

General.

What are monsoons; where and when are they experienced?

Do the limits of the trade-winds vary in different periods of the year?

Atlantic Ocean (Winds).

In what latitude in the Atlantic Ocean, between December and March, will the N.E. Trade probably be met with on the passage from England towards the Equator?

What will be the probable breadth of the belt of variables between the N.E. and S.E. trades in the month of ——?

During what months does the rainy season prevail on the coast of Brazil?

What is the prevalent wind on the African coast, southward of Cape Palmas?

Hurricanes are rarely, if ever, experienced in the South Atlantic. Are there any localities in that ocean visited by storms dangerous to the sailor?

* *See the Sailor's Pocket Book*, 4th edition, Section IV., and Admiralty Wind and Current Charts.

Atlantic Ocean (Currents).

What are the principal currents met with in the navigation of the Atlantic Ocean?

Where do you encounter the Gulf Stream?

Where do you meet the Guinea current?

Where and when is the Equatorial counter current found?

Describe its extent, direction, and general strength.

Where do vessels bound to the eastward round the Cape of Good Hope first encounter the Agulhas current?

Indian Ocean (Winds).

During what months does the S.W. Monsoon prevail?

How far south does it extend?

During which monsoon does the fine season prevail?

Is there any other monsoon known in this ocean beside the S.W. and N.E.?

Where would a vessel generally meet the S.E. Trade on a passage from the Cape of Good Hope to Calcutta?

Indian Ocean (Currents).

Describe the constant currents in the Indian Ocean.

Do the currents of the northern part of the Indian Ocean run with the monsoons?

What is the general force and direction of the currents in the China Sea during the S.W. Monsoon?

Between April and October, what is the general set of the current along the northern coasts of the islands between Java and Wetta?

Pacific Ocean (Winds).

Is there any similarity between the wind systems of the Atlantic and Pacific Oceans?

In general, where would a vessel expect to meet the southern trade when bound to Vancouver's Island from Valparaiso?

On a passage from Honolulu to Valparaiso, how far south would a vessel carry the S.E. Trades in the month of ——?

What are the eastern limits of the S.W. Monsoon of the China Sea, *i.e.* how far is this wind felt in the Western Pacific?

Pacific Ocean (Currents).

What are the principal currents met with in the navigation of the Pacific, or in that part known as the Pacific Station?

How far north is the Peruvian current felt? Is it a warm or cold current?

What is the danger from current on the coast of Chili?

In what latitude is the Equatorial counter current generally found?

Are the current systems on this ocean similar to those of the Atlantic?

Is there any current corresponding to the Gulf Stream in this ocean?

General—Barometer.

In what parts of the several oceans does the barometer stand highest?

What is the average reading of the barometer in the equatorial parts of the several oceans?

What is the general range of the barometer during ordinary weather in the temperate, tropical, and equatorial parts of the ocean?

With what winds does the barometer stand highest in the northern hemisphere?

Is the same law followed in the southern hemisphere?

Thermometer.

How can the thermometer be advantageously used in navigation?

How would it be useful in a passage from Bermuda to Halifax?

On Revolving Storms.*

What distinction do you draw between a common gale and a revolvi storm?

What is the peculiar characteristic of the law of these storms?

* *See Sailor's* Pocket Book, 4th edition, pages 103 to 108.

What is the general rule for heaving the vessel to?

In what oceans do these storms prevail, and in what months?

Satisfied from the prognostics that a storm is approaching, or that you are approaching a storm, you would doubtless make the necessary seaman-like preparations for the security of the sails and spars, and for the safety of the ship; but what would you wish particularly to ascertain?

Finding yourself on the left side of the storm's path in the Southern Hemisphere, what course would you pursue?

Section V.—On their knowledge of the subject of Compass Deviation.*

What compass in the ship do you navigate by, and why?

Are you acquainted with Sir Wm. Thomson's compass?

Describe briefly how the principal mechanical corrections are made.

Describe in detail how the semicircular deviation of this compass can be corrected by means of magnets?

What are the methods usually employed to obtain the deviations of the compass in harbour?

If you are using the method by distant object, how far off should the distant object be?

How do you obtain the deviation of the compass at sea?

What tables have been found to be peculiarly useful in this operation?

Construct a curve of deviations on Napier's diagram?

On what points do you expect to find, in iron-built ships, the maximum deviation?

What masses of iron generally found in a ship, and necessarily in the neighbourhood of the compass, are most prejudicial to its free working?

How far off should movable iron be from the compass?

On what points are the maximum errors of the compass due to heeling of ship found?

* *See Sailor's Pocket Book*, 4th edition, Section II., and Lecky's *Wrinkles in Practical Navigation*, 2nd Edition.

SHIP PAPERS.

The following are the Papers that may be expected to be found on Board a Merchant Vessel. Under Different Nationalities they may vary.

EVERY merchant vessel should carry on board some official voucher for her Nationality, issued by the authorities of the country to which she belongs.

The official voucher of a vessel which belongs to a country possessing a register of its Mercantile Marine, is a certificate of her registry; in other cases its form varies and passes under different names—"passport," "sea-brief," etc.

The Certificate of Registry is a document signed by the registrar of the port to which the vessel belongs, and usually specifies the name of the vessel and of the port to which she belongs; her tonnage, etc.; the name of her Master; particulars as to her origin; the names and description of her registered owners.

The Passport purports to be a requisition on the part of a sovereign power or State to suffer the vessel to pass freely with her company, passengers, and merchandise without hindrance, seizure, or molestation, as being owned by citizens or subjects of such State. It usually contains the name of the Master; the name, description, and destination of the vessel.

The Sea-letter, or Sea-brief, is issued by the civil authorities of the port from which the vessel is fitted out; it is the document which entitles the Master to sail under the flag and pass of the nation to which he belongs; and it also specifies the nature and quantity of the cargo, its ownership and destination.

The Charter-party is the written contract by which a vessel is let, in whole or in part; the person hiring being called the charterer. It is executed by the owner or master, and by the charterer. It usually specifies (amongst other things) the name of the Master, the name and description of the vessel, the port where she was lying at the time of the charter, the name and residence of the charterer, the character of the cargo to be put on board, the port of loading, the port of delivery, and the freight which is to be paid.

The Official Log-book is the log-book which the Master is compelled to keep in the form prescribed by the municipal law of the country to which *the vessel* belongs. **The Ship's Log** is the log kept by the Master for the *information* of the owners of the vessel.

The Builder's Contract is to be expected on board a vessel which has not changed hands since she was built. It is not a necessary document, but it sometimes serves, in the absence of the pass or sea-letter or certificate of registry, to verify the Nationality of a vessel.

The Bill of Sale is the instrument by which a vessel is transferred to a purchaser. It should be required whenever a sale of a vessel is alleged to have been made either during war or just previous to the commencement of a war, and if there is any reason to suspect that the vessel is liable to detention, either as an enemy's vessel, or as a British or allied vessel trading with the enemy.

Bills of Lading usually accompany each lot of goods.

A bill of lading on board a vessel is a duplicate of the document given by the Master to the shipper of goods on the occasion of the shipment; it specifies the name of the shipper, the date and place of the shipment, the name and destination of the vessel, the description, quantity, and destination of the goods, and the freights which are to be paid.

The Manifest is a list of the vessel's cargo, containing the mark and number of each separate package, the names of the shippers and consignees; a specification of the quantity of goods contained in each package, as rum, sugar, etc., and also an account of the freight corresponding with the bills of lading.

The manifest is usually signed by the ship-broker who clears the vessel out at the custom-house, and by the Master.

The Clearance is the certificate of the custom-house authorities of the last port from whence the vessel came, to show that the custom duties have been paid. The clearance specifies the cargo and its destination.

The Muster-roll contains the name, age, quality, place of residence, and place of birth of every person of the vessel's company.

Shipping Articles are the agreement for the hiring of seamen. They should be signed by every seaman on board, and should describe accurately the voyage and the terms for which each seaman ships.

The Bill of Health is a certificate that the vessel comes from a place where no contagious distemper prevails, and that none of her crew at the time of her departure were infected with such distemper.

QUALIFICATIONS FOR CERTIFICATES OF COMPETENCY AS MASTERS OF PLEASURE YACHTS.*

THE examination is purely voluntary, and is to be confined to persons who command their own pleasure yachts. A maker of a yacht who is not also the sole owner is not eligible for examination.

Only one description of certificate will be issued, which will entitle the holder to command his own yacht, whether foreign-going or only cruising within the home-trade limits.

The certificate will not entitle the holder to command any vessel except the pleasure yacht of which he is at the time owner.

Candidates are not required to have served any specified time afloat, as it is believed that their sea knowledge will be sufficiently tested by the examination they will have to pass in seamanship.

Testimonials of service need not be produced.

In other respects the regulations framed for the conduct of the examinations of masters ordinary will apply to these cases, but applications will have to be submitted to the Board of Trade before authority for examination is granted.

He must pass the examination in colours.

In Navigation, etc.—He will be required to give in writing definitions of various astronomical and other terms used in navigation. He must have a competent knowledge of the first five rules of arithmetic, and the use of logarithms. He must be able to work a day's work complete, correcting the courses for deviation, leeway, and variation. He will be required to find the latitude by meridian altitude of the sun, and the difference of longitude from a given departure by parallel sailing; also to find the course and distance from one position to another by Mercator's method. He will be required to find the time of high water at a given port, to observe and calculate the amplitude of the sun, and to find the error of the ship's compass therefrom, and also the deviation, the variation being given. He *must* be able to find the daily rate of the chronometer from error observed,

* From Regulations relating to the Examinations of Masters and Mates in the Mercantile Marine, issued by the Board of Trade, 1881.

and to find the longitude from altitude of the sun by the usual methods. He will be required to find the true bearing of the sun, and the error of the ship's compass from an observed azimuth of the sun, both from an altitude and also from the "Time Azimuth Tables," and with the variation given compute the deviation; to find the latitude from a single altitude of the sun off the meridian, and also to ascertain the true bearing of the sun and the ship's position by Sumner's method by projection.

He must be able to compute the latitude from the meridian altitude of a star, etc.; he must be able to find the magnetic bearing from equidistant compass bearings of any fixed object when at sea, and compute the deviation therefrom. He must construct a deviation curve upon a "Napier's" diagram which will be furnished by the examiner, and understand the practical application of the same, and give written answers to certain practical questions on the effect of the ship's iron upon the compasses, the method of determining the deviation, and compensating same by magnets and soft iron.

He must understand the use of the sextant with its adjustments, and be able to observe with it, and find the index error by the horizon, also by the sun, and read off and on the arc. He must also be conversant with the use of Mercator's chart, and be able to find, on either a "true" or "magnetic" chart, the course to steer and the distance from one given position to another; and find the ship's position on the chart from cross bearings of two objects; from two bearings of the same object, the course and distance between the bearings being given; and also the distance of ship from the object at the time of taking the second bearing. He will also be required to find the course to steer by compass in order to counteract the effect of a given current, and to find the distance the ship will make good towards a given point in a certain time, and to *work out practically* the correction to apply to soundings taken at a given time and place, to compare with the depth marked on the chart.

He must also pass a satisfactory examination in the International Code of Signals.

In Seamanship, etc.—He must give satisfactory answers as to his knowledge of making and taking in sail, and as to the management of a yacht under canvas in moderate, and also in stormy weather. He must have a thorough knowledge of the "Rule of the Road" at sea as regards both steamers and sailing vessels; their regulation lights, and fog and sound signals; and be able to describe the signals of distress, and the signals to be made by ships wanting a pilot, and the liabilities and penalties incurred by the misuse of these signals.

He must also understand the use and management of the rocket apparatus in the event of his vessel being stranded. He must be able to mark and use the lead and log-lines; to cast a vessel on a lee shore; to moor and unmoor a ship; to keep a clear anchor, and to carry out an anchor. He must know how to keep his vessel out of the trough of the sea in the event of accident. How to rig rafts and jury rudders, etc.; and the steps to be taken if his vessel is disabled or unmanageable and drifting towards a lee shore, and as to his resources for the preservation of the crew in the event of wreck. He must also possess a knowledge of what he is required to do by the Merchant Shipping Acts, and a knowledge of the measures he should adopt for preventing and checking the outbreak of scurvy on board; and to answer any other questions relating to the management of a yacht (either steam or sailing) which the examiner may think necessary to touch upon.

Fees.—Candidates for examination, in making their application will be required to pay the examination fee before any step is taken. The fee for examination must be paid to the superintendent of the Mercantile Marine Office in the cash office. In any case in which a candidate offers money to any other officer than a superintendent, and in any place but in the cash office, the candidate so offering money will be regarded as having committed an act of misconduct, and will be rejected, and not allowed to be again examined for twelve months either at the port where the offence was committed, or at any other port.

The fees are £2. If a candidate fail in his examination *no part of the fee will be returned to him.*

IN TRYING RATE OF SAILING.

To find the Distance from a Ship.

To the log. of the height of the masthead of the distant ship in feet, add the log. cot. of the observed masthead angle; the result will be the log. of the distance in feet from the ship.

To find the Distance a Ship is to windward or to leeward.

To the log. of the distance between the two ships, add the log. sin. of *the angle* between a line at right angles to the wind, and the line of bearing *between* the ships; the result will be the log. of the distance to windward.

SECTION X.

STEAM—THEORY OF THE STEAM ENGINE—MARINE BOILERS —BOILER MOUNTINGS—MARINE ENGINES—TYPES OF ENGINES—SLIDE VALVE AND GEAR—INDICATOR DIAGRAMS—EXPANSIVE WORKING AND COMPOUND ENGINES —SURFACE AND JET CONDENSERS—PROPELLORS—INSTRUCTIONS FOR STEAM LAUNCHES AND TORPEDO BOATS.

THEORY OF THE STEAM ENGINE.

Mechanical work consists in the overcoming of resistance by the action of force. It is measured by the product of the resistance, and of the distance through which the resistance is overcome. In British units, the resistance is usually expressed in pounds and the distance in feet; the product is then expressed in *foot-pounds*. The unit of work, or *foot-pound*, is the work done in overcoming one pound resistance through one foot distance.

Energy is a term meaning *capacity for doing work*. The energy, or working capacity represented by the action of a given force through a given distance, is also measured in foot-pounds, by taking the product of the force in pounds and of the distance in feet through which it acts.

Mechanical Energy is the energy a moving body possesses in virtue of its motion. The object of the steam engine is to develop mechanical energy, and apply it to the performance of work.

The term *Power* is used to express *the amount of work done in a given time*. The customary unit is *one horse power*, which represents a performance of 33,000 ft.-lbs. per minute.

In the operation of the steam engine the energy exerted on the piston during any number of complete revolutions is equal to the work done in the same time, whenever the engine is running at a steady speed of revolution. The power may therefore be estimated by finding the product of the mean driving force acting on the piston, and of the distance through which this force acts in a given time. Only the *effective* driving force is taken into account in this calculation; *i.e.* the force available after back pressure has been allowed for.

Let p = *mean effective pressure* on piston (lbs. per sq. inch),
= mean *forward* pressure − mean *back* pressure,
A = area of piston (square inches),
$\therefore p \times A$ = mean effective driving force on piston in lbs.,
Let l = length of stroke (feet),
n = number of *strokes* per minute,
$\therefore l \times n$ = number of feet traversed by piston per minute,
$\therefore p \times A \times l \times n$ = effective work done per minute (ft.-lbs.),

and Indicated horse-power $= \dfrac{p \times A \times l \times n}{33{,}000}$.

This is the actual power developed in the cylinder, it is called indicated

horse-power because the mean effective pressure is found by means of the indicator.

Heat.—The principal physical effects, produced in substances by the application of heat to them, are change of temperature, change of volume, and change of condition or state, by melting, or by vaporization. While a change of state is being produced by heat, the temperature of the substance remains unaltered. Heat thus employed in producing changes in substances without alteration of their temperature is called *latent* heat, while heat so employed as to produce change of temperature is called *sensible* heat.

Measurement of Heat.—Heat is usually measured by the change of temperature it is capable of producing in water. The *British Thermal Unit* is the quantity of heat necessary for raising the temperature of 1 lb. of pure water through 1° Fahrenheit.

This is practically (not strictly) independent of the temperature of the water. Thus 100 B. T. U. will raise 100 lbs. of water through 1°; 1 lb. through 100°; 10 lbs. through 10°, and so on.

The *Mechanical Theory* of Heat is the theory by which heat is regarded as a form of energy. This theory is founded on the facts that heat may be produced by the expenditure of mechanical energy in various ways, and *vice versâ*; and, as proved experimentally by Dr. Joule, that in overcoming friction, the quantity of heat produced is in all cases strictly in proportion to the quantity of mechanical energy expended, viz. 1 B. T. U. per 772 ft.-lbs. The quantity 772 ft.-lbs. is therefore regarded as the equivalent of the unit of heat, and is called the *mechanical equivalent of heat* or *Joule's equivalent*.

Steam.—In the ordinary operation of the steam engine, steam is produced in the boiler under a certain pressure, which is kept constant by proper management of the fires. During a portion of the piston's stroke in either direction steam is freely admitted to the cylinder, an equal quantity of steam being meanwhile produced in the boiler; a certain amount of work is thus done by the displacement of the piston through the volume of the steam admitted. The steam in the cylinder is then cut off from communication with the boiler, and is allowed to drive the piston, by expansion, through the remainder of the stroke. Additional work is thus done by the further displacement of the piston during expansion. Finally the steam escapes from the cylinder to the condenser or into the air, and the piston is driven back by the action of steam, which is admitted and allowed to expand in a similar manner on the other side of the piston.

The following are some of the more important facts in connection with *these processes.*

1. The temperature of steam in the normal condition is dependent on its pressure, and is the same as the boiling point of pure water under that pressure. The greater the pressure, the higher is the temperature.

2. The density of steam in the normal condition is approximately *proportional* to its pressure. At the atmospheric pressure the volume per pound is 26·36 cubic feet.

3. The heat expended in producing steam of temperature T° from water of temperature $t°$ is, *per pound of steam*,

Sensible heat (for raising water to boiling point) = $T - t$ B. T. U.'s.
Latent heat (for evaporating the water) = $966 - \cdot 7\,(T - 212)$.
Total heat required (sensible + latent) = $T - t + 966 - \cdot 7\,(T - 212)$.

4. The total heat required to convert water of any given temperature into high pressure steam is only a little more than that required to convert the same weight of water into low pressure steam; the difference is about ·3 B. T. U. per degree difference of temperature.

5. The latent heat of evaporation is spent in doing work. The great increase of volume accompanying evaporation is resisted *externally* by the pressure on the water, and *internally* by the cohesion of its particles. The latent heat does the work of overcoming these resistances. The *external* work of evaporation, however (*i.e.* the work of overcoming external resistance) represents only a small fraction of the latent heat, the greater part being absorbed in doing *internal* work.

6. When steam is allowed to expand, its pressure falls according to the law, pressure $\propto \frac{1}{\text{volume}}$, *approximately*. The exact relation between the pressure and volume of expanding steam, however, depends on the condition of the steam during expansion. The total work done in driving the piston through v cubic feet is equal to $p \times v \times 144$ ft.-lbs. where p is the average steam pressure (lbs. per sq. inch) exerted through the volume v.

7. This work is obtained by the disappearance of an equivalent quantity of heat.

The *work done before cut-off* is in reality the external work of evaporation, and is due to that portion of the latent heat which disappears in doing external work; while the *work done during the expansion* is due to heat expended by the steam itself. This expenditure of heat by steam during expansion, though directly beneficial (inasmuch as it produces an equivalent amount of work which is entirely additional to the work obtainable from the same steam without expansion) is the cause of a partial condensation of the

expanding steam, and, indirectly, this tends to detract more or less from the economy due to expansive working. The moisture formed by condensation and deposited on the cylinder metal, absorbs heat from it during exhaust and passes away as vapour; the cooled cylinder is then re-heated by the hot entering steam, only to be again cooled during exhaust; hence a loss of heat.

8. One method of dealing with this difficulty is to surround the cylinder with a jacket of steam with the object of supplying heat through the cylinder metal, so as to prevent as much as possible the deposition of moisture on the interior surfaces, and thus reduce the cooling effect just referred to; a second method is to *superheat* the steam, in which condition it is less liable to liquefaction; a third method is that of dividing the required expansion between two or more cylinders as in the compound engine, whereby liquefaction is more easily prevented, and is also of less importance.

9. The process of superheating steam in practice consists in supplying heat to it when it is separated from water and free from moisture; the result is to raise its temperature independently of its pressure. Thus, if the arrangements be such that the pressure is kept constant, the temperature may still be raised to any extent by superheating; at the same time the density of the steam will be diminished.

In its normal condition as produced from water, steam is a saturated vapour, *i.e.* at any given pressure it has the greatest density possible for steam of that pressure; it is therefore called saturated steam. In this condition steam possesses only just as much heat as is necessary for its existence as steam at the particular pressure; while, in the superheated condition, it possesses an excess of heat above what is absolutely necessary. For this reason superheated steam does not become liquefied as readily as saturated steam by expansive working. With highly superheated steam, however, damage results to the interior of the cylinder from the drying up of the lubricants by the hot dry steam. Considerable trouble has also been experienced with the superheaters themselves, and, since the introduction of high-pressure steam, the system has fallen into disuse.

10. **Condensation.**—On contact with cold substances, steam condenses with great rapidity, and by taking advantage of this property we may remove it almost completely from the cylinder when its work is done. In the simple condensing steam engine, the steam is allowed to escape at the end of the stroke to the *condenser*, where by contact with cold water or cold metal it is condensed to water. The air pump withdraws the air and water from the *condenser*, and thus a *vacuum* is maintained in the condenser, and is produced *also in the* cylinder by opening communication with the condenser.

The *back pressure* resisting the return of the piston is thus greatly reduced, with advantage as regards both power and economy. The so-called vacuum in the condenser is imperfect from the presence of uncondensed water vapour and unexhausted air, causing together in a good condenser, a pressure of about 1½ lbs. to 2 lbs. per sq. inch. These pressures correspond to 27 inches and 26 inches respectively on the *vacuum gauge*, which is constructed to show in inches of mercury the difference between the condenser and atmospheric pressures; thus

If atmospheric pressure	= 30 inches
And vacuum gauge	= 26 „
Condenser pressure	= 4 „ or 2 lbs. per sq. inch.

The back pressure in the cylinder is usually not less than 3 lbs. per square inch, the excess being due to want of area in the communications.

11. The water from the condenser of a marine engine is pumped into the boiler at a temperature of about 100° Fahr., is there converted into steam, and, after doing work in the cylinder, is again condensed and brought back to the same temperature. The heat abstracted from the steam, in order to condense it is less than the heat spent in producing it; for a certain amount of work having been done an equivalent amount of heat has disappeared.

If heat expended in producing steam from condenser feed = A
Heat abstracted from steam in condenser = B
Heat-equivalent of effective work done in cylinder = C
Then, neglecting radiation

$$A - B = C$$

And Efficiency of the Steam $= \frac{C}{A}$.

MARINE BOILERS.

THE plates of which boilers are constructed are of wrought iron or of mild steel. The use of the latter material is now becoming general for the outside or *shell* plates on account of its superior strength, and for the *internal* parts also it is now frequently used. The steel used has a tensile strength of about 26 to 30 tons per square inch, the wrought iron about 20 tons.

Shell.—The boiler shell with low-pressure steam is of rectangular or box form, a form which, though economical of space, is essentially weak. The necessary strength is obtained by tying the opposite plates together by

stays, but without inconveniently close staying, the boiler cannot be made to carry more than about 35 lbs. steam gauge pressure. For higher pressures a cylindrical form of shell is used, the curved portion of which becomes stronger as the thickness of plates is increased or the diameter of shell reduced, and, being self-supporting, requires no staying. The flat ends require to be stayed.

Internal Parts.—Ordinary marine boilers are of the *tubular* kind. The *furnaces*, passing from the boiler front, open at the inner end into *combustion chambers*, from which a large number of tubes are led either to the front or back end of the boiler, where they open into the *smoke box* which communicates by the *uptake* with the funnel. In navy boilers these tubes are usually of brass, and about three inches in diameter. The furnace gases pass from the furnaces into the combustion chambers and through the tubes, and these parts are surrounded by the water, the level of which is about nine inches above the upper tubes. The metal of these parts, excepting that of the furnaces and combustion chambers below the fire-grates, acts to transmit heat to the water, and is called the *heating surface*. The steam collects in the *steam chest* or space above the water. Within each furnace is a *fire-grate*, terminated at the inner end by the *bridge*. The air necessary for combustion passes into the lower part of the furnace called the *ash-pit*, and through spaces left between the fire bars to the fuel on the grate; air is also admitted through the furnace door direct to the upper part of the furnace, and, in navy boilers, a sliding shutter fitted at the inner end of the ash-pit allows air to be admitted direct to the lower part of the combustion chamber. The object of this fitting is to prevent smoke.

Types of Boilers.—Navy boilers are classified as *rectangular* or *circular*, according to the form of shell, and as *high* or *low* according to the arrangement of parts adopted in order to adapt them to the available space.

1. *High Rectangular* or *Box Boiler* (Figs. 1 and 2), fitted to ships of moderate and large size using low-pressure steam. The shell is of the box form; the furnaces, A A A, three to six in number, have flat sides, but are arched outwards at the top and bottom; the combustion chambers B are near the back of the boiler, and the tubes return over the furnaces to the uptake D in the front of the boiler.

The plates both of the shell and of the internal parts are everywhere supported by wrought iron stays which pass through the water spaces and steam chest and tie the opposite plates together.

Thickness of plates, pressure 30 lbs.—

Shell, Furnaces, and Combustion Chambers, $\frac{7}{16}$ inch.

Bottoms of Shell, Furnaces, and Combustion Chambers, $\frac{1}{2}$ inch.

Tube plates, $\frac{3}{4}$ inch.

Fig. 1

Fig. 2

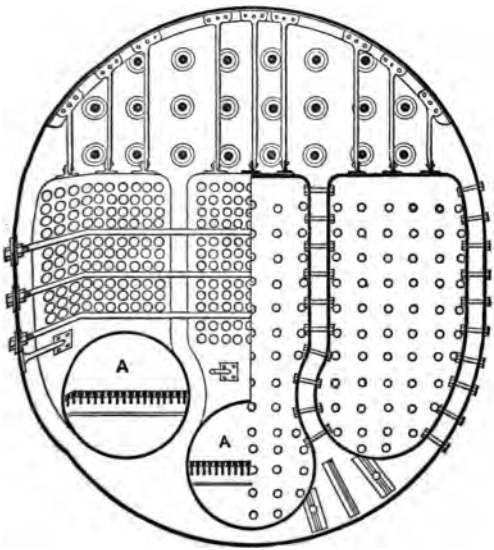


Fig. 3

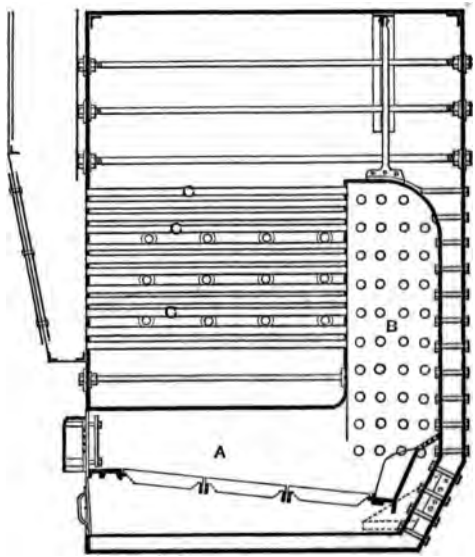


Fig. 4

2. *Low Rectangular Boiler*, fitted to sloops and gun vessels using low-pressure steam. The peculiarity consists in the situation of the tubes, which are alongside or between the furnaces, instead of being above them. This enables the height of the boiler to be reduced.

3. *High Circular* or *Oval Boiler* (Figs. 3 and 4), fitted to the larger classes of vessels using high-pressure steam. The combustion chamber B is near the back of the boiler, and the tubes C C C return over the furnaces to the front, as in the high rectangular type. The upper and lower parts of the shell of the boiler are circular in section, and joined together by flat plates which are stayed to each other by long stays running across the boiler (see Fig. 3). By this means the requisite amount of tube surface can be readily obtained, without unduly increasing the diameter of the boiler. The furnaces A A (the latter two or three in number), are circular in section, and therefore require no staying, the necessary strength being obtained by using a proper thickness of plate. The furnaces being of comparatively small diameter are of much thinner plates than the shell. To strengthen them against the danger of collapse, to which any distortion of form renders them liable, they are usually made in two or three lengths, the joints between which, being stiff, serve to support the furnace tube (see *r r* Fig. 5). The end plates of the shell are flat, and these, as well as the plates of the combustion chambers, require to be stayed.

Thickness of plates (shell 13 or 14 feet diameter), pressure 60 lbs. to 90 lbs.—

Shell $\frac{7}{8}$ inch (iron) to $\frac{7}{8}$ inch (steel).
End plates $\frac{9}{16}$ inch to $\frac{3}{4}$ inch.
Furnaces and Combustion Chambers, $\frac{1}{2}$ inch.
Tube plates $\frac{3}{4}$ inch.

The Double-ended Boiler is another modification. Furnaces (two or three) pass from *each end* to combustion chambers in the middle of the boiler, and the tubes return over the furnaces to the two boiler fronts.

4. *Low Circular* or *Cylindrical Boiler* (Figs. 5, 6, 7), fitted to gun vessels and sloops using high-pressure steam, and to the class of corvettes fitted with an underwater steel deck. The object is to reduce the diameter of the boiler. There are two furnaces A A having a common combustion chamber B, from which the tubes C C C pass to the *back end* of the boiler, the upper tubes being level with the furnace crowns. The *hanging bridge* H deflects the furnace gases into the lower part of the combustion chamber. The diameter of the boiler is thus reduced while the length is increased. The end plates and the combustion chamber plates are stayed.

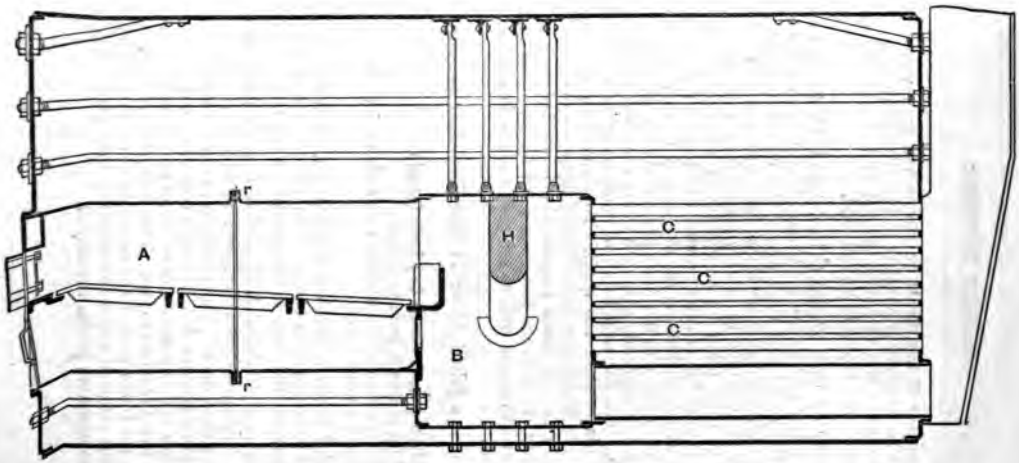


Fig. 5

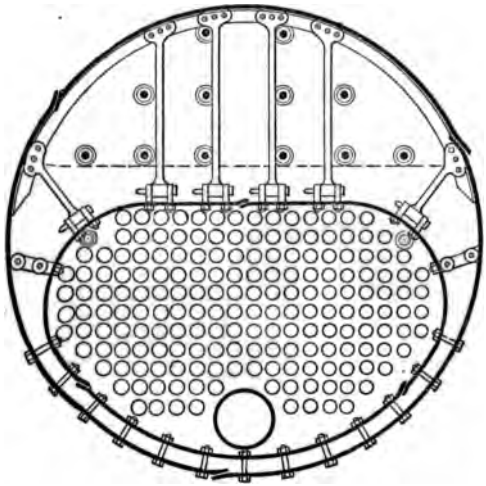


Fig. 6

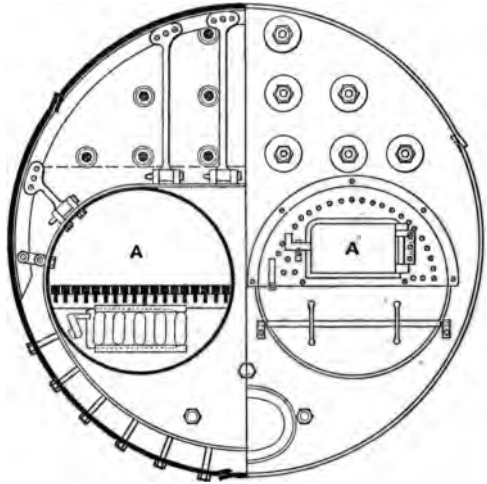


Fig. 7

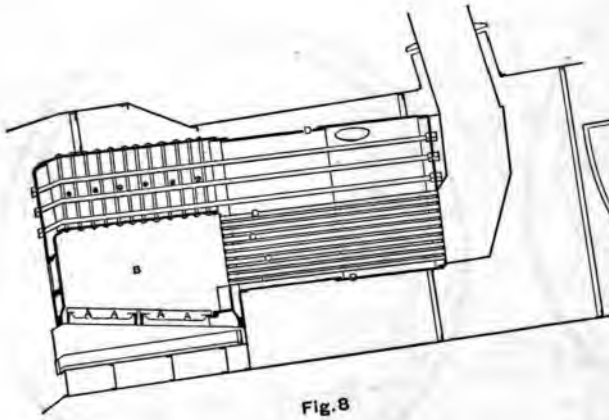


Fig.8

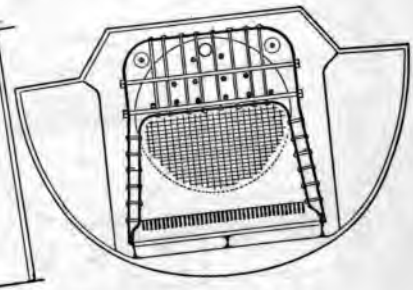


Fig. 9

Thickness of plates (shell 8 or 9 feet diameter), pressure 60 lbs. to 90 lbs.—
Shell, end plates, and tube plates $\frac{3}{8}$ to $\frac{1}{16}$ inch (shell plates steel, for the higher pressure.)
Furnaces and combustion chambers $\frac{1}{2}$ inch.

5. *Locomotive Boiler* (Figs. 8 and 9), fitted to torpedo and other steam boats, and carrying pressures up to about 130 lbs. per square inch. This boiler is specially adapted for rapid evaporation, and is worked with a forced draught, which is obtained in torpedo boats and in recent steam pinnaces by producing an air pressure in a closed stoke hold by means of a blowing fan.

The grate A A A is at the lower part of the *fire box* B, which is within the *fire box shell;* both fire box and shell are open at the bottom. The tubes (iron, $1\frac{1}{4}$ to $1\frac{1}{2}$ ins. diam.) C C C are contained within the *barrel* D D, which is of circular section. The end plates and fire box plates are stayed.

In torpedo boats full speed can only he maintained continuously for about *three hours*, owing to the fouling of the fires and tubes. Fresh water should be used in these boilers.

Thickness of plates (barrel 3 feet 3 inches diameter)—
Shell, barrel, and fire box $\frac{3}{8}$ inch.
End plates $\frac{1}{2}$ inch.

Boiler Mountings.

Navy Boilers are provided with the following fittings.

Safety Valves, for preventing the pressure from rising above a certain point by affording, when necessary, a sufficient escape for the steam. Two or three valves are fitted to each boiler, situated in one valve box and loaded to the working pressure by weights or springs. Spring loaded valves are now preferred on account of the load being unaffected by the heeling or pitching of the ship. An objectionable feature, however, is that in rising to relieve the boiler they compress their springs, thereby increasing the load, so that the steam pressure may still increase although the valves are blowing off. This may be reduced by using long springs and special forms of valve.

Gear is now fitted for lifting the safety valves by hand from the stoke hold and from the deck above.

Alarm Safety Valve. A small valve loaded to about 3 lbs. per square inch above the safety valve load, and intended to blow and call attention if the safety valve fail to act properly.

Stop or *Communication Valve*, for making communication between the steam chest and the main steam pipe. The valve-box communicates with the

steam chest by the *internal steam pipe*; a thin brass pipe extending across the steam chest and closed at the end, but having fine slits cut in its upper surface for the passage of the steam. This fitting is intended to check the passage of water. Stop valves now act automatically; that is to say, when a regulating stop is screwed back, the valve is free to open or close according as the pressure is greater in the boiler or in the main steam pipe; thus the passage of steam *into the boiler from the main steam pipe* is prevented by the valve becoming closed. This is intended to operate in the event of a rupture occurring in one of a set of boilers in communication, the sudden fall of pressure within causing the valve to close and thus isolating the injured boiler.

Blow out Cocks or *Valves*, for discharging water from the boiler into the sea. On opening the *bottom blow out cock* or *valve* on the boiler and the *blow out Kingston*, water is discharged from the bottom of the boiler by the *bottom blow out pipe*.

On opening the *surface blow out* or *brine cock* and Kingston, surface water is discharged from the water level by the *surface blow out* or *brine pipe*. The lighter foreign matter may thus be discharged from the surface, and the heavier matter from the bottom.

The *bottom blow out* apparatus is used also for running up the boiler from the sea before raising steam.

Feed valves, main and auxiliary, for regulating the admission of feed water.

The *main feed valve* regulates the feed supplied by the *main feed pumps* from the condensers, which is available while the engines are working. The *auxiliary feed valve* regulates the auxiliary feed, which may be supplied from the sea whenever necessary, by the *auxiliary feed* or *donkey pump*. These valves are usually simple lift valves which close automatically whenever the main feed pumps are stopped, thus acting as non-return valves. An internal feed pipe is fitted to deliver the water clear of the plates.

Glass Water Gauges for showing the water level in the boiler; usually two to each boiler. The gauge consists of a glass tube, packed at the ends, and placed in communication at the upper end with the steam and at the lower end with the water in the boiler, the water level is then visible in the glass.

The glass is now fitted on a steady pipe which communicates with the upper part of the steam chest and with the lower part of the water space; this conduces to steadiness within the glass. The centre of the glass is at the ordinary working level.

Water Gauge Cocks, for use in the event of the glass gauges being broken or unserviceable. These are cocks placed at different levels, which may be opened to ascertain if the water is above or below them respectively.

Steam Pressure Gauges (Bourdon's) two to each boiler. These act on the principle that a coiled tube of flattened section tends to straighten under internal pressure. One end of such a tube communicates with the steam chest, the other end is closed, but free to move, and its movement is shown by a pointer on a dial.

The pressure indicated is the *excess* of the steam pressure above the atmospheric pressure in lbs. per square inch.

MARINE ENGINES.

The Cylinder.—Fig. 10 is a section of an ordinary horizontal navy cylinder. A is the cylinder proper, bored out to the correct diameter and fitted with the piston P. B is a rough cylindrical shell surrounding A, but standing clear of it so as to leave a steam-tight space about an inch deep around its circumference; this space *j j j* is the *steam jacket*. At the ends are the *cover* and *bottom*, C and D, which are made double and supplied with steam to complete the steam jacketing; the cover C is a separate piece secured by nuts.

The construction now adopted for cylinders is as follows:—

The working barrel or *liner* A is a separate casting; the outer shell is cast with one end, the bottom, complete, and the liner is afterwards secured in place by a flange *i* at the inner end, which makes a steam-tight joint with the bottom. At the outer end the liner fits into the outer shell, and steam tightness is obtained by packing the small space left beyond. The ring *r r* secures the packing in its place.

With this construction the liner is free to expand or contract lengthways under changes of temperature. It may also be made of harder metal than the rest of the structure, and may easily be renewed if necessary.

The outer shell is of cast iron, the liner is of harder cast iron, or of steel, to withstand wear. Whitworth's compressed steel is now very generally used.

The steam enters and leaves the cylinder by *steam* passages c d, leading from orifices *a b* at the ends to *steam* ports s s, t t in the cylinder face, a

plane surface on the outside of the casting on which the slide valve works. In the centre of the cylinder face is the *exhaust port e*, communicating by the *exhaust passage h* with the condenser. The action of the slide valve, which opens and closes these communications, will be explained later. It works on a false face *f f f* of hard cast iron secured to the cylinder face, and is situated usually at the side in horizontal cylinders, its weight being taken on a guide surface beneath.

The cylinder cover is at the back end; at the front end the cylinder is secured to the engine main frames, which are bolted down to the bearers. The cylinders, slide casings, steam pipes, etc., are clothed in felt encased in wood to prevent radiation.

Cylinder Fittings.—*Escape Valves* for affording an outlet for any water which may find its way into the cylinder when the engines are at work. One is fitted at each end, opening outwards against the resistance of an adjustable spring. The valve is forced open and the water discharged by the impact of the piston on the water.

Relief or *Drain Cocks*, for draining the cylinder of water at any time; one at each end. They are opened by hand, and are used before and during starting, and whenever necessary.

Auxiliary Starting Valve, for assisting in starting the engines. This is a small slide valve moved by hand over a face with ports and passages similar to those for the main slide valve. By moving this valve steam may be admitted to either side of the piston and exhausted from the opposite side. These valves are also used for warming and clearing the cylinders of water before starting.

Piston.—The piston should be steam tight, yet work with as little friction as possible. For steam tightness the piston must be packed at its circumference; for this purpose metallic packing is used.

The ordinary construction for navy pistons is as follows:—

A A the body of the piston (Figs. 11 and 12), is a hollow cast iron di having internal ribs R R R for stiffness. On one face is a flange *f f* at t circumference; on the opposite face the *junk ring* J J is secured, forming corresponding flange, and between these flanges is held the *packing ring* This is a cast iron hoop which, after having been turned to the correct diame has been cut through at one part (Fig. 14), and is thus free to be pressed *against the* cylinder, for which purpose the steel springs *s s s* (Fig. 11) *placed behind it.* The springs of navy pistons are generally of the "oc

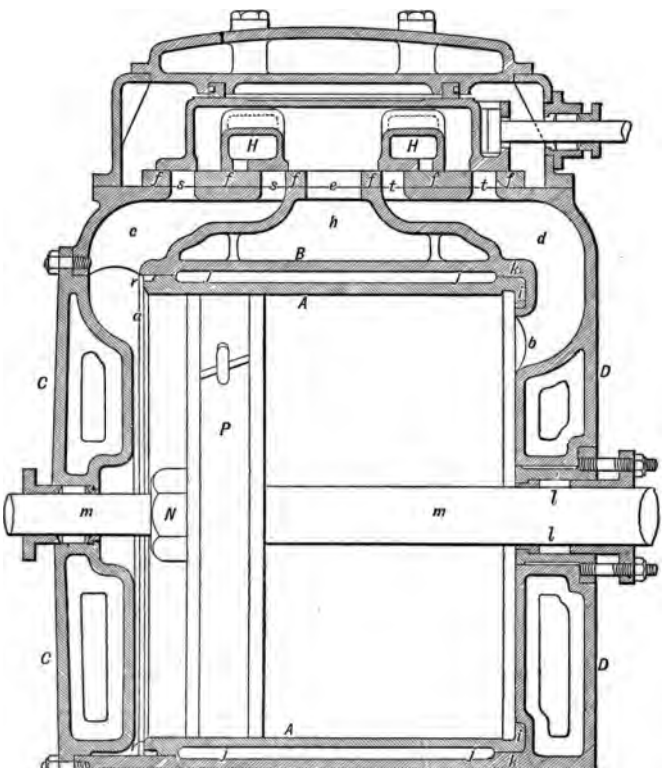


Fig. 10.

Fig.11.

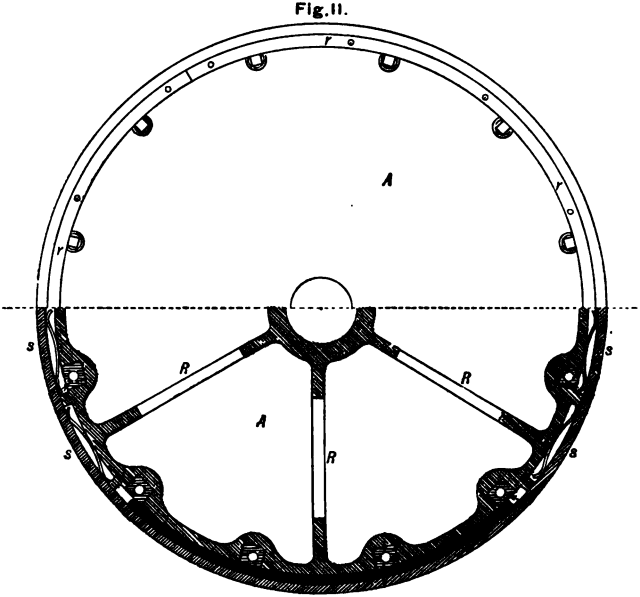


Fig.12.

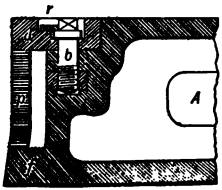


Fig.13.

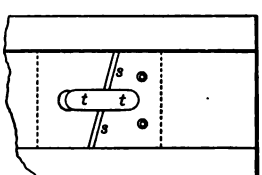


Fig.14.

spring" form shown. In horizontal cylinders piston springs are fitted only for about three-quarters of the circumference, the space between piston body and packing ring being filled in solid at the lower part by a *filling piece* to support the weight on the broad surface of the packing ring.

Leakage by the slot *s s* (Fig. 14) in the packing ring is prevented by a *tongue t* and *covering plate*, the former fitting across the slot, the latter closing it on the underside.

The junk ring J (Fig. 13), keeps the above-named parts in place, and the bolts *b* by which it is secured are prevented from working loose by the light wrought iron *guard ring r r r* (see Fig. 11).

The *Piston Rod m m* (Fig. 10) transmits the motion of the piston; it is a solid rod of wrought iron or steel to which the piston is secured, generally, as shown, a nut N tightening the piston up on a coned part of the rod. Two piston rods are sometimes used. It is desirable to have a guide for the piston rod motion at the back of the cylinder as well as in front (see Figs. 15, and 18), the two guides then serve to support the piston and reduce the wear of the cylinder. The piston rod passes through a *Stuffing box, l l.*

Rotatory Motion.—The cylinder is fitted with a steam-tight piston which is driven forward and backward along the cylinder through a definite stroke, by the action of pressure exerted alternately on its opposite faces.

The object being generally to produce rotation of a line of shafting, a connecting rod and crank are used to transmit motion from the piston to the crank shaft. The distance *a b* (Fig. 15) from centre of crank pin to centre of shaft is the crank throw or *radius;* this is one half the piston's stroke.

The connecting rod *c c* connects the piston or the piston rod cross-head, as the case may be, with the crank pin, the ends of the rods being suitably constructed to form free working bearings. The tail end of the connecting rod *d* receives the reciprocating motion of the piston, and is compelled to move in a straight line by means of a guide *g g*. The force transmitted along the connecting rod causes the crank to turn about the centre of the shaft, this being the only motion possible.

When the crank lies in the line of the piston's motion, the thrust or pull along the connecting rod will have no tendency to turn the crank. In these positions the crank is on the *dead points*. In other positions of the crank there will be more or less turning effort according to the angle of the crank and the effective force exerted on the piston.

On the whole, the effective work done in the cylinder, excepting loss by friction, is given out at the crank pin in the course of a complete

revolution: but the work of rotation is always more or less irregular, the turning effort twice becoming zero and twice reaching a maximum value in the course of each revolution. This irregularity causes increased stress on the material of the shaft and unevenness of motion, and is increased by expansive working, and to some extent also by shortness of the connecting rod.

The difficulty of the *dead points* is met in land engines by using a fly wheel, and in marine engines by coupling two or more engines together, to turn the same line of shafting, the cranks being set in different positions. The usual plan is to use two cranks set at right angles to each other, or three cranks are used and are set at equal angles to each other, *i. e.* at 120° apart.

The plan of using coupled engines greatly reduces the inequalities of the turning effort above referred to.

It is important that the connecting rod be not too short, for a short rod not only increases the irregularity in turning effort, but also causes increased friction at the guide and the bearings of the connecting rod, involving increased wear and tear and loss of power.

Where practicable the length of connecting rod is at least four times the length of crank.

Types of Engines.

The *screw engines* now in use in the navy are of three types as regards the arrangement of the moving parts, viz. the *Direct-Acting*, the *Trunk*, and *the Return-Connecting Rod* types.

Direct-Acting Engine (Figs. 15 and 16).—In this arrangement there is usually a single piston rod to which the tail end of the connecting rod is attached directly outside the cylinder bottom. The connecting rod therefore works between the cylinder and the shaft. A block *b b* is carried at the outer end of the piston rod, and is made in two parts, which are suitably formed to receive between them a pin carried in the tail end of the connecting rod. The block is adjustable to the pin, so as to form a working bearing. The block serves also to guide the piston rod by sliding in contact with a fixed guiding surface *g g*.

In horizontal engines of this type another guide is usually provided at the *back end of the* cylinder, and the two guides take together to some extent the *weight of the* piston. The engines are arranged to rotate for ahead in the *direction indicated* by the arrow, so that the deflecting force at the piston rod *end may act* downwards and so be taken on the guide. This involves the

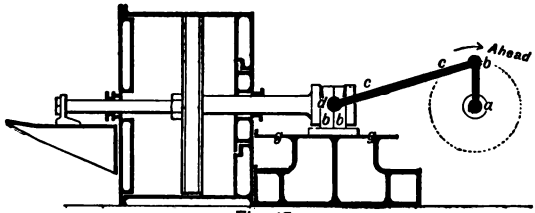


Fig. 15.

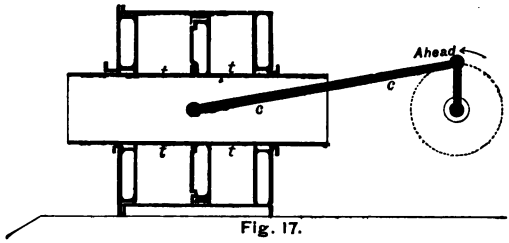


Fig. 17.

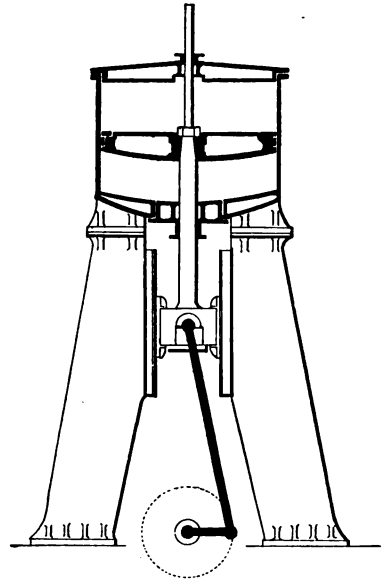
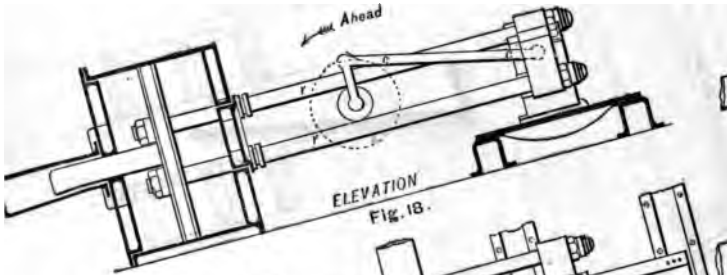


Fig. 16.



ELEVATION

Fig. 18.

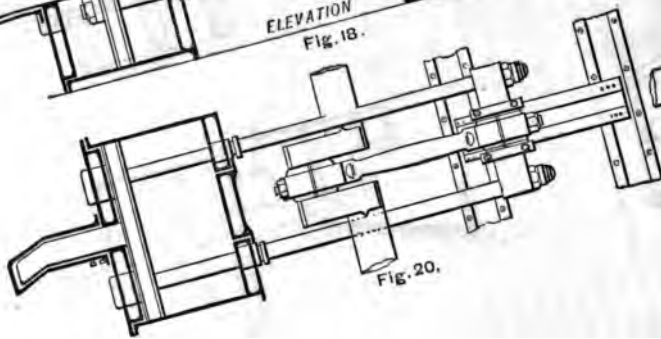


Fig. 20.

Fig. 19.

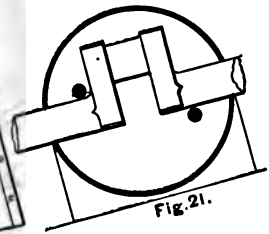


Fig. 21.

use of a right-handed screw if the cylinders are on the port side, a left-handed screw if the cylinders are on the starboard side.

In Vertical or Inverted engines (Fig. 16), the cylinders are free from the rapid wear occasioned in horizontal cylinders by the weight of the piston. The vertical arrangement in armoured vessels, fitted with twin screws, readily admits of subdivision of the engine room by a middle-line watertight bulkhead. In unarmoured vessels, where it is essential that the machinery should be below the water line for protection, vertical engines cannot be used.

Trunk Engine (Fig. 17).—In this arrangement the piston rod is dispensed with, with the effect of increasing the space available for the other parts. The large tube or *trunk t t* attached to the piston passes through the cylinder working steam tight through the front and back covers. The tail end of the connecting rod is attached to a pin carried in the middle of the trunk, *i.e.* at the centre of the piston, and the trunk is of sufficient diameter to allow of the oscillating motion of the connecting rod. By thus bringing the *tail* or *gudgeon* bearing within the cylinder, space is saved and a longer connecting rod may be fitted. The trunk stuffing boxes act as guides and no others are necessary.

This engine is rotated for ahead in the opposite direction to that of the direct-acting engine, in order that the thrust at the gudgeon may act upward instead of downward, for a downward thrust would here be taken on the cylinder and stuffing boxes. Trunk engines, therefore, with the cylinders on the port side are fitted with a left-handed screw.

The trunk engine is a good mechanical arrangement, and works exceedingly well, though with considerable friction in the trunk stuffing boxes. It has a disadvantage, however, when a high degree of economy is aimed at, the loss, resulting from the alternate cooling and reheating of the cylinder metal, when steam is worked expansively, being increased in trunk cylinders by the presence of additional metal in the form of the trunk, which acts in the same way as the cylinder metal.

Return-Connecting Rod Engine (Figs. 18, 19, 20, 21).—In this arrangement the space available for the working parts is increased by placing the connecting rod *c c* beyond the shaft, *i.e.* on the side opposite to the cylinder. Two piston rods *r r* pass across the shaft, clear of the shaft and of the crank arms (see Fig. 21), and are secured to a crosshead (Fig. 19), which is suitably constructed for the attachment of the tail end of the connecting rod and also for acting as a guide for the piston rod ends. The connecting rod returns to the crank pin. A back guide for the piston is usually fitted.

The ahead direction of this engine also is the reverse of that of the direct acting engine, but with the same object, viz. that the thrust may be *downward* on the piston rod guide. This involves the use of a left-handed screw with cylinders on the port side.

This arrangement, though not quite so simple as the two others, gives the desired length of connecting rod without the disadvantage of the trunk. The piston rod guide, however, is not so well placed as in the direct-acting for giving support to the piston and for retaining its truth as a guide, and it occupies space otherwise available for the condensers. The arrangement, however, is more frequently fitted than the direct-acting for horizontal engines on account of the limited space available.

Oscillating Engine.—This is an arrangement very successfully employed for *paddle engines.*

The difficulty arising from want of space is here met by the omission of the connecting rod. The piston rod head is fitted with brasses for direct connection with the crank pin, and the cylinder is suspended by two trunnions in bearings, so as to be free to oscillate and follow the movement of the crank pin.

The trunnions are hollow, and serve also for the passage of the steam to and from the cylinder, the steam pipe being led into one trunnion and the exhaust pipe into the other. Steam and exhaust passages cast around the cylinder connect the steam and exhaust trunnions respectively with the slide valves, of which there are usually two to each cylinder, on opposite sides in order to maintain equilibrium.

The oscillating arrangement is an excellent one for the comparatively low revolutions required for driving the paddle wheel. The majority of paddle engines now in use are of this type. For the higher revolutions necessary for driving the screw it is not suitable.

Paddle engines are in some cases of the direct-acting type, placed in an inclined position to obtain the necessary length of connecting rod.

Slide Valve and Gear (*See page* 513).

Slide Valve.—In Fig. 22 the simple locomotive slide valve is represented on the cylinder face. The movement of the valve during the stroke *of the* piston, is as follows:—At the commencement, the port *s* is slightly open *to steam,* and the port t well open to exhaust, the valve then moves in the *same direction* as the piston until the port t is fully open to exhaust and the

port *s* usually about two-thirds open to steam. The valve then commences to return, and by the time the piston has reached say, ·7 of the stroke, will have closed the port, thus stopping the entry of the steam. Continuing its return the valve next closes the port *t* by which vapour has been passing to the condenser; from this point the vapour still in the cylinder will be compressed by the advancing piston, the object being to prevent shock. Passing the central position the valve next commences to open the port *s* for the release of the expanding steam. Lastly, a little before the crank reaches the dead point, the valve commences to open the port *t* to admit steam for the return stroke, so that at the end of the stroke there is already a certain amount of opening to steam.

The valve is now in a similar position to that occupied at first, but relatively to the other end of the cylinder; and the piston, now returning, we have a similar series of operations, the valve continuing its travel until the port *s* is fully open, then returning and successively closing *t*, closing *s*, opening *t* and opening *s*, during the completion of the double stroke.

The four operations above described as occurring in order during the stroke, are called, respectively, "*cut-off*," "*compression*," "*release*" and "*admission*."

Lead of the slide valve is the distance the port is uncovered to steam when the piston is at the commencement of its stroke.

Lap, outside and *inside*, is the distance the valve flange overlaps the steam port on the outer and inner edges, respectively, *when the valve is in its central position.*

Double-ported Slide Valve (Fig. 10).—The slide valves now generally used in marine engines are *double-ported, i.e.* the valve is constructed for working on a cylinder face which has two steam ports at each end, these are opened and closed simultaneously. Steam has access to the inner ports by the passages (H H). The lap, the lead, and the travel of the valve are only one half as much as would be required with the simpler form of valve. The operations performed and the manner of performing them remain unaltered.

Slide Valve Gear.—The gear for working the slide valves of marine engines is so arranged that by means of it the engines may be started and worked either ahead or astern or may be stopped. The arrangement in general use is the *link motion*, consisting of two distinct eccentrics fixed on the shaft in the correct positions respectively for ahead and for astern motion, and so connected with the slide valve that either the ahead or the astern eccentric may be made to give it motion. The eccentrics are set at the

proper angles in advance of the crank, in the two directions of rotation, the eccentric radii occupying positions similar to *Oa Ob* Fig. 23, where *Oc* is the crank radius. These angles are always greater than 90°; the excess over 90° is the *angular advance.*

The eccentric rods *r r* (Fig. 23) are attached to the end of a link L L which is sometimes solid, but usually has a curved slot down the centre. A block B B fits the slot and is attached to the slide valve rod C.

The link is suspended by a rod *d* about the outer end of which it swings when in motion. By means of hand or steam starting gear connected with this rod, the link may be moved up or down, past the block, and may be fixed in any position.

When the link is placed in either of the two extreme positions one of the eccentrics is out of gear while the other is in full gear and give motion to the valve. If the link be moved so as to bring the block nearer the centre the travel of the valve becomes reduced and its operations are advanced relatively to the piston's stroke. The steam may thus be cut off earlier in the stroke and worked more expansively. By bringing the block to the centre of the link the engine may be stopped, the valve's motion being then so much advanced that the piston cannot complete a stroke in either direction.

The links of a set of engines are moved together. In order to start it is necessary to admit steam to the slide chests and move the links into the proper position. Should there be any difficulty, the auxiliary slide valves may be used as required.

Indicator Diagrams.

An indicator diagram from the cylinder of a steam engine is a figure which represents, on a known scale, the variation of pressure on one side of the piston during a complete revolution. Such a figure is obtained by means of the *indicator*, an instrument consisting essentially of a small cylinder, fitted with a piston, and capable of being placed in communication at the lower end with either end of the engine cylinder, whilst the engine is at work. Above the indicator piston is a spiral spring of known strength, for regulating its movements, and the upper part of the cylinder is open to the air. When the communication is made, the variation of pressure on the under side of the indicator piston causes it to rise and fall in a manner corresponding to the rise and fall of pressure within the steam cylinder. A pencil, moving with the indicator piston, traces the diagram on a card, which has a transverse *reciprocating* motion, corresponding to the motion of the steam piston. The *pressure* at each point of the double stroke is thus registered. A similar

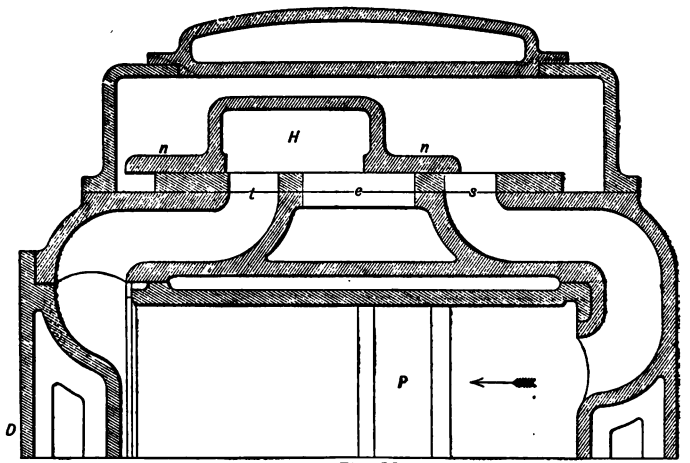


Fig. 22.

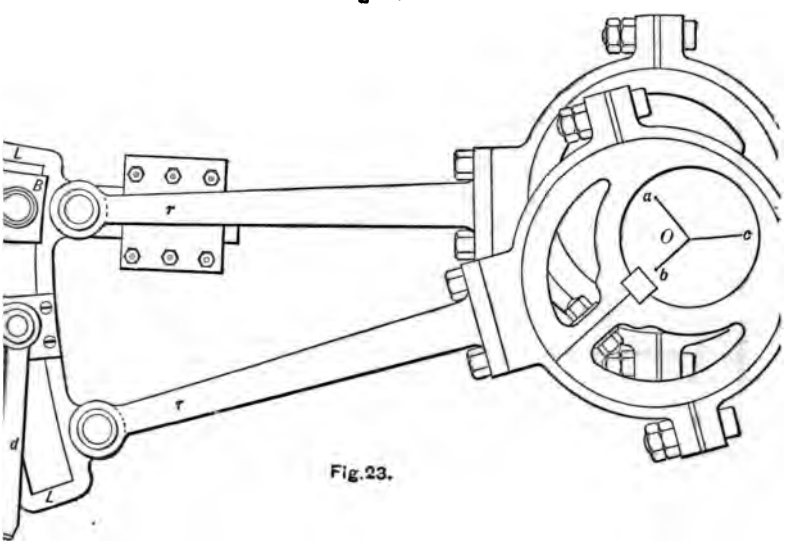


Fig. 23.

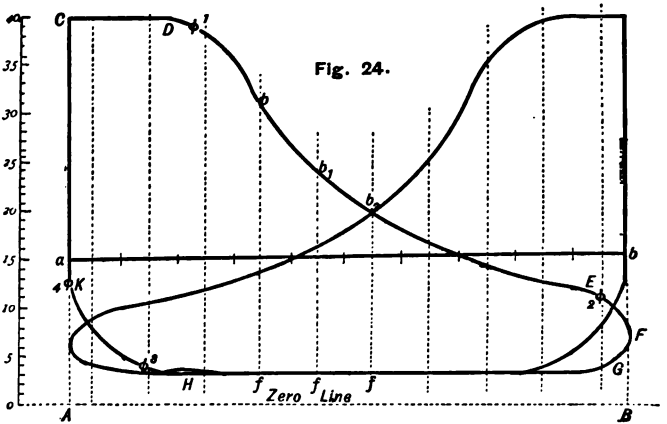

C
D
1
b
b1
b2
a
b
4
K
E
2
F
G
8
H
f Zero
f Line
f
A
B
40
35
30
25
20
15
10
5
0

Fig. 24.

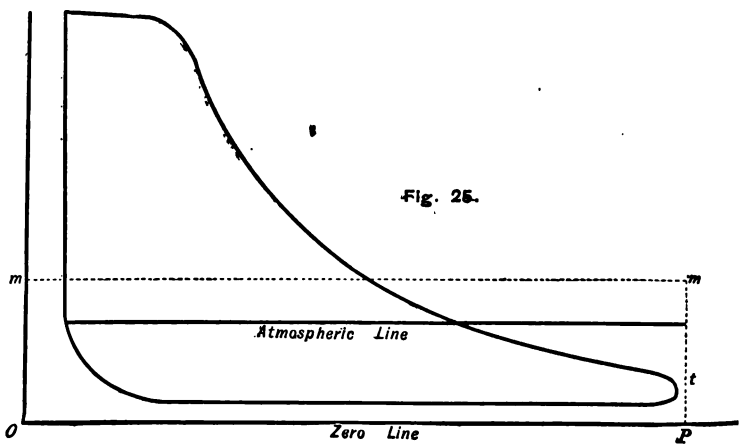

m
m
Atmospheric Line
t
O
Zero Line
P

Fig. 25.

diagram being taken on the same paper from the other end of the cylinder, a complete representation is obtained of the variation of pressure on the piston during a revolution.

The diagrams obtained from simple expansive condensing engines, under good conditions, are illustrated in Fig. 24. The steam is supposed to be cut off at about quarter stroke by an expansion valve.

a b is the *atmospheric line*, drawn by the instrument. Its position represents atmospheric pressure vertically, its length represents the length of stroke.

The dotted line A B, parallel and equal to *a b*, has been drawn for convenience to represent the stroke.

Suppose the indicator to be in connection with the end A of the cylinder, and the piston to arrive at A, and to be about to start again towards B when the pencil is brought into contact with the paper. At this moment the pencil rises to C, under the action of the initial steam pressure. As the piston moves forward from A, the pencil traces the line C D. At point of the stroke marked 1, the steam is cut off, and, while the piston advances under the action of the expanding steam, the pencil draws the curved line D E. At point 2, *release* of the steam commences, and during the completion of the stroke the falling line E F is drawn. The piston then commences the return stroke, and the pencil traces the falling line F G, while the release continues, and then the line G H more or less parallel to the atmospheric line. At point 3, in the return stroke, *compression* of vapour commences, during which the rising line H K is drawn. At point 4, the steam port is opened for *admission* of steam, and the pencil rises, drawing the line K C as the piston comes again to A. The figure being now complete, the pencil is removed from the paper.

Measurement of the Diagram.—One important use of indicator diagrams is to enable us to find the mean effective pressure exerted on the piston, which is an essential element in the calculation of the power (Fig. 24).

The vertical distances, $f\,b$, $f\,b^1$, $f\,b^2$, represent the excess of the steam pressures during the forward stroke over the back pressures during the return stroke. By taking a sufficient number of such measurements at equidistant points in the stroke, we may find the *mean effective pressure* on one side of the piston. Similarly the mean effective pressure on the other side may be obtained, and consequently the mean effective pressure for the whole cylinder.

The usual method of finding this quantity is as follows:—The atmospheric line is divided into ten equal parts, and a line is drawn through the middle point of each of these parts across the diagrams perpendicular to the atmospheric line. The lengths intercepted on these lines between the upper and

lower lines of one of the diagrams as $f\,b$, $f\,b_1$, $f\,b_2$, etc., are then measured either by an ordinary scale of inches, or by a scale of pounds corresponding to the scale of the indicator spring. The ten measurements obtained are added together and the sum is divided by ten; the result, if in inches, is converted into pounds pressure by means of the scale. The number so obtained is the mean effective pressure for the diagram measured. A similar process gives the mean effective pressure for the other diagram. The mean of these two numbers is the mean effective pressure for the cylinder in pounds per square inch.

Expansive Working and Compound Engines.

Expansive Working.—The advantage of working steam expansively may be illustrated as follows:—

Fig. 25 represents an expansive diagram, below which is drawn the line $O\,P$ to represent the zero of pressure. From this line the forward or back pressures may be measured. Suppose the mean pressure during the forward stroke to be represented by the height of the line $m\,m$, *i.e.* by $P\,m$. The pressure at the end of the stroke if the expansion were continued so far would be $P\,t$. This pressure may be taken as a measure of the steam used per stroke which is evidently *a cylinder full at pressure* $P\,t$. Now suppose *the same work is to be done without expansion.* For this to be the case, the mean forward pressure must be the same as before, assuming the back pressure to remain unaltered. The steam must therefore be admitted at the pressure $P\,m$ throughout the entire stroke, and the steam used per stroke will be a *cylinder full, at pressure* $P\,m$. The density of steam being proportional to its pressure, it is clear that *the weight of steam used to do the same work* would be less in the first case than in the second, in the proportion $\frac{P\,t}{P\,m}$, and the farther the expansion is carried the smaller this fraction becomes. The expenditure of fuel is approximately proportioned to the weight of steam used; the gain theoretically is therefore evident.

The great advance in economy realized since the early days of marine propulsion has resulted chiefly from the development of expansive working.

Simple Engines.—In the simple expansive engines commonly used, *until* within the last few years, the desired expansion is given in each *cylinder*, independently, by cutting off the steam at a proper point of the *stroke*, the steam being discharged from each cylinder to the condenser at the *end of the* expansion.

With this system great difficulty exists in securing economical results on account of the loss of heat resulting from the alternate cooling and re-heating of the cylinder metal, previously explained on page 490. This loss is due to the wide difference of temperature to which the cylinder metal is exposed, and to the deposition of moisture on the metal, during the admission and expansion of the steam, and subsequent evaporation of the moisture during exhaust. This evaporation takes place very readily under the low condenser pressure, the moisture absorbing a large quantity of heat from the internal surface of the cylinder. In this cooled condition the cylinder receives steam, producing partial condensation, and absorbs heat, which is subsequently wasted in re-evaporating the moisture.

The loss resulting from this action tends to increase with increased expansion, because the range of temperature is greater, and there is greater difficulty in preventing the formation of moisture.

A waste occurs in all cylinders from the necessity of filling the *clearance spaces* at each stroke, the steam admitted being inefficiently used. In simple engines this waste increases with increased expansion. It is difficult also to arrange suitable cut-off gear for great expansion in simple engines; very early points of cut-off being necessary on account of the clearance spaces.

The employment of great expansion in simple engines is also accompanied by a serious drawback, viz. that the *initial* steam pressure being necessarily very high in comparison with the mean pressure, unduly severe strains are brought on the machinery, conducing to wear and tear, and to risk of accident.

For these reasons the simple engine has been found unsuitable for the employment of high rates of expansion.

Compound Engines.—The principle of the compound engine is that the desired expansion is divided into stages, taking place successively in different cylinders, so that in any one cylinder the range of temperature and the tendency to liquefaction correspond only to a part of the whole expansion. The expansion is at present usually divided into two stages only. The first part of the expansion is carried out in the high pressure cylinder, which receives the steam from the boiler in the ordinary way. The expansion given in this cylinder is moderate, ranging from, say, twofold at full power, to, say, fivefold at low power. On being exhausted from this cylinder the steam passes to the low pressure cylinder, which is of greater volume than the high in the proportion of, say, three or four to one. The steam still expanding drives the low pressure piston, until, at the end of the stroke it fills the low pressure cylinder, from which it is then discharged to the condenser in the usual way.

The total expansion employed is evidently the expansion given in the first cylinder multiplied by the ratio between the volumes of the two cylinders.

Types of Compound Engines.—Figs. 26, 27, 28, show three arrangements of the cylinders of compound engines now commonly used.

Fig. 26, is the Woolf or tandem type. Each engine has two cylinders of different diameters placed in a line, so that the two pistons are on the same rod and work together. The two cranks are at right angles as usual. The steam is received from the boiler into the high pressure cylinder A, cut off and expanded; at the end of the stroke it has access to the low pressure cylinder B, which it enters during the return stroke. From B it is exhausted to the condenser. Steam passes in a similar manner through the cylinders A_1 and B_1 of the other engine.

Fig. 27, is the two cylinder type. In this arrangement the high pressure cylinder A is the cylinder of one engine and the low pressure cylinder B is the cylinder of the other engine. The cranks are set at right angles, consequently the high and low pressure pistons do not work together, and it has therefore been customary to employ an intermediate vessel or *receiver* to receive the steam from the high pressure cylinder, until at the proper time it is allowed to enter the low pressure cylinder. The *receiver* usually surrounds the high pressure cylinder, communicating with the exhaust passage of the high pressure and with the slide valve chest of the low pressure cylinder. In some cases a large pipe is the only receiver between the two cylinders.

In comparison with the Woolf type this arrangement requires only half the number of cylinders, but they are of larger dimensions for any given power. The whole of the steam used per stroke when fully expanded is here contained in the single low pressure cylinder which must therefore have a capacity equal to the sum of the two low pressure cylinders of the Woolf engine, or of the two cylinders of a simple engine, having the same initial pressure, expansion, and power. The large size of the low pressure cylinder in powerful engines of this type becomes objectionable, and a modification known as the *three cylinder type* (Fig. 28) is now generally adopted with large powers.

Two low pressure cylinders B and C are here used to receive the steam from the high pressure cylinder A and complete the expansion, and both of *these* exhaust to the condenser. The three pistons work separate cranks *which* are usually placed at equal angles to each other, *i.e.* 120° apart. The *only receiver* between the high and low pressure cylinders is the pipe connect-

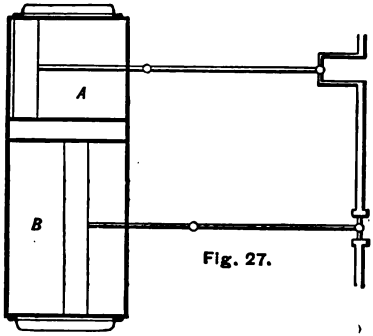


Fig. 27.

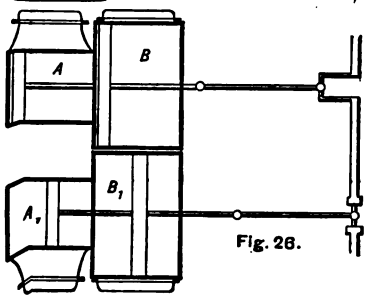


Fig. 26.

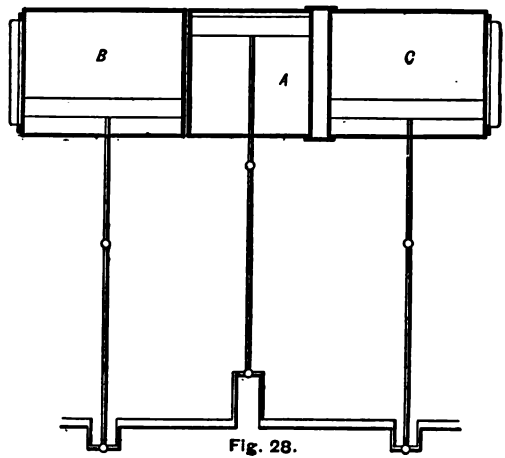


Fig. 28.

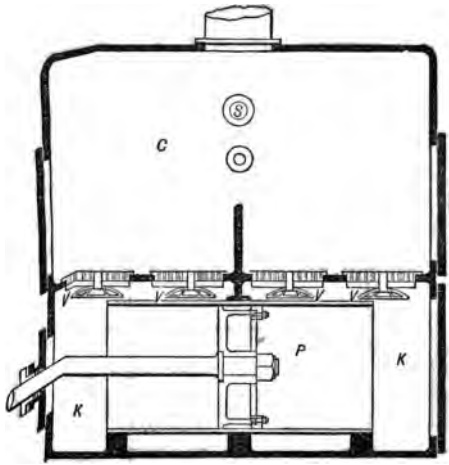


Fig. 29.

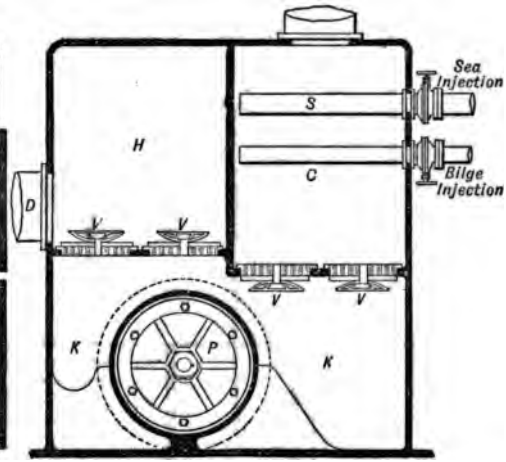


Fig. 30.

ing the high pressure exhaust passage with the low pressure slide valve chests.

The success of the compound system in point of economy is thoroughly established, and may be explained by the fact that owing to the moderate degree of expansion employed in each cylinder, the metal is exposed to a smaller range of temperature, and there is less liquefaction; consequently the loss of heat by the cooling and re-heating of the cylinders is less than in simple engines. The loss by clearance, also, is comparatively small. In this system economy is obtained without the disadvantage of producing the severe straining actions on the machinery above referred to.

SURFACE AND JET CONDENSERS.

Condensers.

Figs. 29 and 30 show sections of a jet condenser. The steam, after doing its work in the cylinder, is led to a large chamber C called the *condensing chamber*, where it meets with a jet of cold sea water. The water is introduced to the chamber by a pipe S with a number of slits or holes in it called a *spray* pipe. The effect of this is to divide the water into a number of small streams thus condensing the steam and forming a vacuum. The condensed steam and water fall to the bottom of the air-pump chamber K and are pumped by means of the *air pump* P into the *hotwell* H. Some of this water is pumped back again to the boiler by the feed pump, but the larger part is discharged overboard by the *discharge valve* D. Sea water contains one-twentieth of its volume of air at the ordinary pressure of the atmosphere, and this would collect in the condenser and spoil the vacuum. The air pump P pumps out this air, any uncondensed vapour and water from the chamber C, and maintains the vacuum.

The foot and delivery valves *v v v v* of the air pump are generally made of vulcanized indiarubber, circular in shape. The valves are fitted over a gun-metal grating, and on the upper surface of the valve is fixed a guard to prevent the valve from lifting too high.

Bilge Injection Pipe is a pipe leading from the condensing chamber to the engine-room bilge and fitted with a grating to prevent chips, etc., getting to the condenser. In the case of a serious leak and the engine-room bilge becoming filled with water, the necessary water for condensing the steam

can be obtained by this means from the bilge by opening the bilge injection valve and closing the sea injection valve.

Salts in Sea Water and Boiler Scale.—Sea water contains in solution chiefly chloride of sodium (common salt), sulphate and carbonate of lime, and sulphate of magnesia. Common salt is soluble in water at all temperatures, but at a temperature of about 300° Fahr., the sulphate of lime is deposited on the boiler plates, thereby forming a hard scale which is a bad conductor of heat.

To reduce the amount of scale formed on the plates, some of the water in the boiler is blown out and its place supplied by the less dense sea water.

To prevent scale forming on the plates of the boiler and the loss resulting from blowing out (sometimes 15 per cent. of the whole value of the fuel burnt) the *surface condenser* was introduced.

Figs. 31 and 32 show a vertical surface condenser. The steam passes *through* a number of small brass tubes and the cold sea water is circulated round the tubes by means of a pump called a *centrifugal pump*. The condensed steam is pumped by the air pump P, in this case vertical, to the hotwell, and the whole of it pumped by the feed pump to the boiler. The tubes (which have been omitted for the sake of clearness) are secured to the tube plates AA, BB and are parallel to the stays S S S S. The tubes are made water-tight at the ends, and free to expand and contract under changes of temperature by small screwed glands and tape packing. A circulating plate CC (Fig. 32) is fitted in the condenser for circulating the water more thoroughly around the tubes. The course taken by the circulating water is shown by the arrows.

Sea Injection.—A spray pipe S is shown in the upper part of the condenser (Fig. 32) into which sea water is admitted. In the event of the circulating pump breaking down, the condenser can be turned into a common jet condenser.

Auxiliary or surplus feed pipe is a small pipe for admitting sea water to the condenser or hotwell to make up any waste of fresh water which may take place.

Boiler Deterioration.—With the introduction of the surface condenser a very serious drawback was experienced. It was found that the boilers of ships using surface condensation became deteriorated in a very rapid manner. *This was* found to be due principally to the presence of moist air in the boilers, *and most* of the precautions that have been adopted are on the basis of *excluding* moist air from the boilers, or of neutralizing its effect when present.

FIG.31.

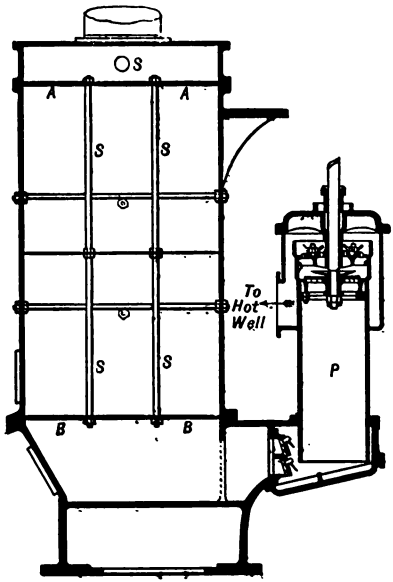
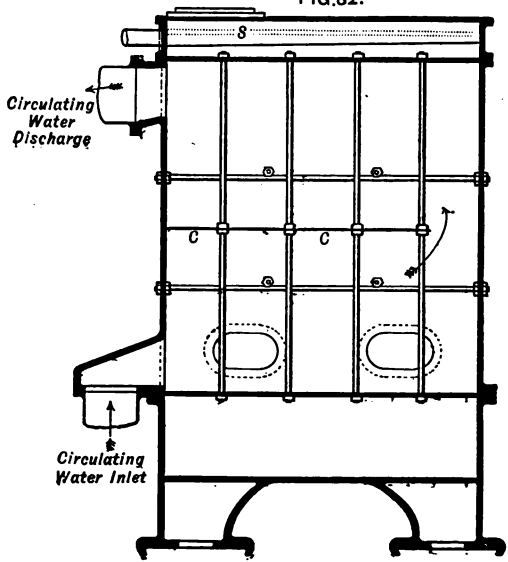

S
A
A
S
S
S
S
B
B
To
Hot
Well
P

FIG.32.


S
Circulating
Water
Discharge
C
C
Circulating
Water Inlet

Zinc plates, in good metallic contact with the plates or stays of the boiler and suspended below the water level, are found to afford complete protection against corrosion, whether arising from the water itself, galvanic action, or air admitted with the feed.

Pumping Power.

The pumps used in a large armoured ship for pumping water from the bilge are:—

1. Centrifugal circulating pumps for surface condenser which are worked by separate small engines, and discharge the bilge water through the condensers overboard, or by a separate discharge valve overboard.

2. Engine bilge pumps, worked by the main engines.

3. Fire engine worked by a separate small engine.

4. Auxiliary bilge engines, two in number, worked by separate small engines.

5. Friedmann's ejectors. A jet of steam is admitted to a large pipe discharging overboard. A branch from this pipe is led down into the bilge or other part required to be readily cleared of water. On admitting steam to the discharge pipe a partial vacuum is formed in the suction pipe, and thus the bilge water is discharged overboard.

COMBUSTION.

COMBUSTION may be defined as the rapid chemical union of the oxygen of the air with the hydrogen and carbon present in the fuel whereby heat and light are evolved. The chief combustible constituents of coal are carbon and hydrogen, and their chemical combination with the oxygen of the air is the source of heat used in steam boilers.

The following table gives approximately the composition of North Country and Welsh coals:—

	North Country.	Welsh.
Carbon in a free uncombined state	50 per cent.	80 per cent.
Hydro-carbons or volatile matter	36 „	12 „
Impurities	14 „	8 „

Combustion of Coal.—There are two distinct stages in the combustion of coal. (1) The formation and combustion of the gaseous or volatile parts of the coal. (2) The combustion of the solid residue.

1. When a fresh charge of coal is thrown on the fire, the coal absorbs, at first, heat from the fire to liberate the hydro-carbons or volatile matter which is present in the form of pitch, tar, naptha, etc. These are driven off from the coal, and the solid carbon or red hot coke is left on the fire bars.

These gases, called light and heavy carburetted hydrogen, are split up into carbon and hydrogen by the great heat of the furnace (about 2000° Fahr.) and combine with the oxygen of the air, forming carbonic acid and water vapour.

This air is supplied principally through the perforations in the furnace door. When the temperature of the furnace is not sufficiently high to ensure the complete combustion of the carbon, or the air supply is insufficient, the unburnt carbon, in the condition of a very fine black powder, is swept away up the funnel with the issuing cloud of vapour, and is called *smoke*.

2. After the gases are driven off, there remains on the bars red hot coke or nearly pure carbon. The oxygen of the air passing through the air spaces between the bars, combines with the carbon producing carbonic acid and we thus get *complete combustion*. If, however, the fires are thick this carbonic acid becomes changed to carbonic oxide on its passage through the glowing coke, and, unless more oxygen be supplied to it above the fire, the gases pass away as carbonic oxide, and two-thirds of the heat due to the combustion of the carbon is lost. We have then *incomplete combustion*.

The amount of air required per pound of coal burnt is about twenty-four pounds with a chimney draught.

Qualities required in Coal for a Man of War.—(1) Evaporative Efficiency. (2) Absence of smoke. (3) Ready ignition and rapid combustion. (4) It must not cake on the bars nor yet split up or decrepitate when heated. (5) Cohesion and ability to bear exposure without deterioration. (6) Close stowage.

The Welsh coal evaporates 15 per cent. more water per pound of coal burnt than North Country, and owing to the small amount of hydro-carbons present burns with little or no smoke. For these reasons Welsh coal is preferred for service in ships on the home stations, but for ships on foreign stations, owing to the better preserving qualities of the North Country coal and its ability to bear exposure, a mixture of two-thirds Welsh and one-thiid North Country is used.

Fig. 33.

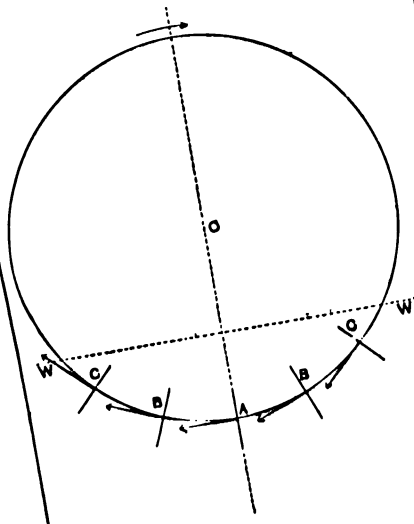


Fig. 34.

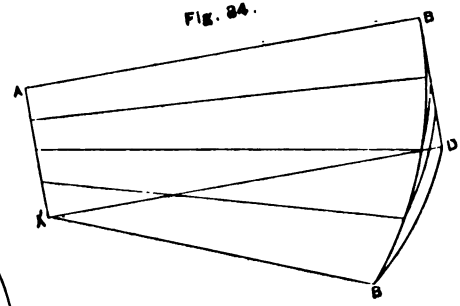
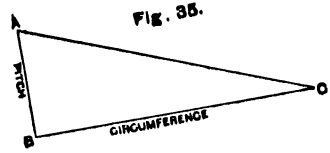


Fig. 35.



PROPELLERS.

Radial Paddle Wheel.—In this form of wheel the floats are bolted direct to the arms of the wheel, so that the pressure produced on the water by the floats, when the wheel is put in motion, is always at right angles to the radius of the wheel.

It is clear that at any instant the only float that produces a directly sternward reaction is the one which is in a vertical position at the lowest point of the wheel. The other floats which are immersed have a vertical component tending to raise or depress the vessel, which is entirely wasted so far as propulsion is concerned. In Fig. 33. W W shows the water line, A, B, C, paddle floats. The float A being vertical exerts a direct sternward pressure on the water, while the others B, B, C, C, have the direction of pressure as shown by the arrows.

Feathering Paddle Wheel.—To obviate the oblique action of the floats in the radial wheel, the feathering paddle wheel was introduced. The floats are carried on joint pins, and their motion is controlled by the action of an eccentric or eccentric pin through rods and levers in such a manner that the floats are approximately vertical during their passage through the water, so that the whole of the thrust is in a sternward direction.

The objections to the use of the paddle wheel for ocean navigation arise from the difficulties attending the variation in immersion for long voyages, due to the lightening of the ship by consumption of coal. For short voyages, where the draught of water is practically unchanged, paddle wheels are employed with advantage.

The Screw Propeller.

The screw propeller is the name given to a set of metallic blades fixed to a large boss and placed obliquely on a horizontal shaft revolved by means of the engines. Each blade of a screw propeller is a certain proportion (about one-sixth) of the thread of a screw of large pitch and considerable depth, relatively to the pitch.

The surface of a screw propeller is generated by a straight line moving uniformly along and always at right angles to the axis, and at the same time revolving uniformly around it. Suppose AB (Fig. 34) at right angles to AA′ to move uniformly along AA′ and at the same time to revolve around it uniformly, the surface developed by AB will be a screw surface of uniform pitch.

Pitch.—If AB made a complete revolution the distance of A′ from A measured parallel to the axis is called the pitch of the screw. *It is the distance between two consecutive threads measured parallel to the axis.*

Length of the Screw.—An actual blade consists only of a portion of a revolution, and the extreme dimension of the blade, measured parallel to the axis, is called the length of the screw. If we take a right-angled triangle ACB (Fig. 35) and wind it on a cylinder whose circumference is equal to CB the base of the triangle, then AC would be a spiral or helical curve, and AB would be the pitch, the angle ACB is called the *angle of the screw.*

Hence $\frac{\text{pitch}}{\text{circumference}}$ = tangent of the angle of the screw.

Diameter of the Screw is the diameter of the circle formed by the tips of the blades when revolving. Figs. 36 and 37 show different views of a four-bladed propeller as now fitted. Fig. 36 shows a longitudinal section through the axis of the propeller, only one blade is shown, the remainder being attached to the three faces AAA. The stern shaft S (Fig. 37) is cased in brass and works in *lignum-vitæ* bearings in the stern tube. This shaft fits in a conical hole in the boss of the propeller and is secured by means of a nut on the end of the shaft and a key fixed in the shaft. The blades are separate from the boss, and are secured by means of seven bolts, as shown in Fig. 38. The bolts are completely cased in by means of plates, so that the whole of the surface of the boss presents no projections, and there is less disturbance of the water as the boss revolves. A conical cap is fitted over the nut at the end of the shaft for the same reason. The form of the *expanded blade* (Fig. 37) *i.e.* the blade laid flat, is elliptical. Various forms have been adopted, but the prevailing practice is now to make it a pointed ellipse.

Alteration of Pitch.—The holes in the flanges of the propeller blades are made oval, so that each blade can be twisted a certain amount and thus the pitch altered.

The after side of the propeller being the acting surface preserves the exact form of the screw surface; the forward face being modified by the thickness that must be provided to give the necessary strength.

The number of blades fitted to a propeller is either two or four. For ships that are intended to keep the sea for a considerable time and to make passages under sail, the two-bladed propeller is used. The resistance offered by the propeller, when sailing, is considerable; and to obviate or reduce this, the following plans have been adopted.

1. Lifting Screws.—On the end of the screw-shaft a cheese coupling is keyed, with a rectangular slot running across it. The boss of the propeller

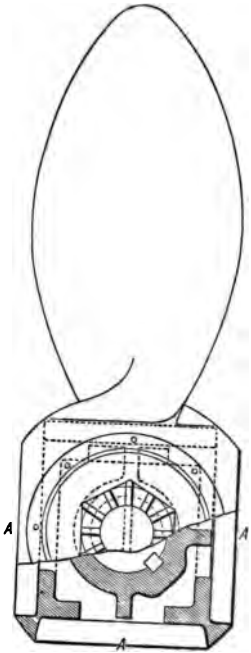


Fig. 36.

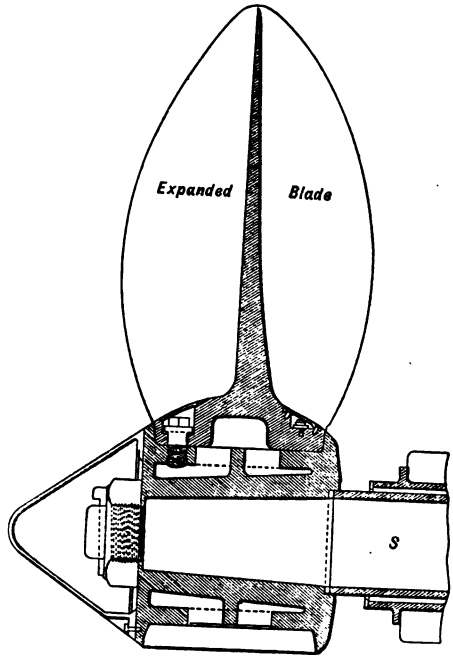


Fig. 37.

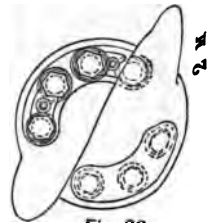


Fig. 38.

has journals formed on the forward and after sides. The forward journal has a T head formed on it which, when the propeller is in its place, fits into the slot in the cheese coupling, and the rotation of the screw-shaft is thereby transmitted to the propeller. The journals of the propeller boss work in bearings in the banjo frame, which rests in chairs or bearings formed in the rudder post. When the slot in the cheese coupling is placed vertical the banjo frame and propeller can be hoisted clear of the shafting and completely out of the water. The weight of the propeller, banjo frame, etc., is considerable, and strains the ship very much. The large apertures or screw wells necessary, interfere seriously with the structural strength of the ship. The wear on the couplings and bearings is also great, and is difficult to repair without docking the ship. This has now been superseded by the use of:

2. *Feathering Screws.*—In these the blades are so fitted as to be turned in a fore and aft direction when the ship is under sail, so that they produce but little retarding effect on the vessel, and have the additional advantage of enabling the propeller to be set at any required pitch.

3. *Revolving Screws.*—In large, armoured ships which are not intended to use sail power, and which depend wholly on their engine power for propulsion, the screw shaft is disconnected from the engines, and the propeller allowed to revolve. This very much reduces the resistance offered by the fixed propeller when the ship is in motion.

These ships are generally fitted with *twin screw engines*, two sets of engines being used to drive two independent propellers fixed one under each counter and so arranged that the upper blades work outwards. The starboard engine is fitted with a right-handed screw, and the port engine with a left-handed screw. When one engine is disabled, the other engine can be utilized to propel the ship at about three-quarters full speed, the disabled propeller being allowed to revolve. In order to disconnect the engines from the propeller, the coupling bolts in one of the couplings are withdrawn, the screw shafting at the same time being kept fixed by means of a brake fitted for this purpose. The advantages of twin screws are:—

1. Less liability to total disablement of machinery, as two sets of engines are used.

2. Superior handiness, as the ship can be manœuvred with great facility by working one engine ahead and the other engine astern.

3. Capability of steering the ship if the rudder is damaged or disabled.

4. With vertical engines, a continuous longitudinal bulkhead can be fitted throughout the engine and boiler rooms, thus subdividing them very completely.

Two-bladed screw propellers are used with all lifting and feathering propellers, and four-bladed screws are used in all our armoured twin screw ships.

Action of a Screw Propeller.—If a screw works in a fixed solid nut the screw advances, for each revolution, in the direction of its length a distance equal to the pitch of the screw. It is impossible to turn the screw in the nut without producing motion lengthwise in the screw. Now when the propeller revolves in the water, the same kind of action takes place; the oblique blades of the propeller press against the water, the tendency being to produce motion in a fore or aft direction. If the water could not move backward, the ship would move forward a distance equal to the pitch of the screw. But the water is incapable of resisting the pressure brought on it by the screw; it yields to the pressure, and therefore the advance of the ship through the water is always less than the pitch of the screw owing to the motion of the water backwards. The amount of this *slipping back* of the water from the screw constitutes *real slip* of the screw, though it is not what is generally known as slip.

Slip (as generally used) is the difference between the speed of advance of the screw, due to the pitch and revolutions, and the speed or actual advance of the ship relatively to still water.

Let p = pitch of screw in feet

r = revolutions of screw per minute

V = speed of ship in feet per minute

Then $p\,r - \text{V}$ = slip of the screw in feet per minute.

Example:—Given the speed of a ship 13½ knots, the pitch of the propeller 20 feet, and revolutions per minute 80, find the slip.

$$\left.\begin{matrix}\text{Speed of ship in feet}\\ \text{per minute}\end{matrix}\right\} = \frac{13{\cdot}5 \times 6080}{60} = 1413$$

$$\left.\begin{matrix}\text{Speed of screw in}\\ \text{feet per minute}\end{matrix}\right\} = 80 \times 20 = 1600$$

$\therefore$ Slip in feet per minute = 187.

Slip is generally expressed as a per centage of the speed of the screw.

$$\therefore \text{Slip per cent.} = \frac{187}{1600} \times 100 = 12 \text{ per cent.}$$

Resistance.—The most important element in the resistance to a ship's motion, in well-formed ships, is the frictional action of the water on the skin

of the ship. The most important feature in the action of a screw propeller as affecting its efficiency is the effect it produces on the water under the stern of the ship. In the absence of the propeller the water displaced at the bow by the passage of the ship would tend to close in under the stern and cause a pressure there. The action of the screw withdraws this water and consequently diminishes the pressure of water under the stern, which is equivalent to increasing the resistance of the ship. This was investigated by the late Mr. Froude, who gave it the name "Augment of Resistance," and he estimated in some cases that it was 40 per cent. of the whole resistance of the ship.

Let R = resistance of ship in pounds
V = speed of ship in feet per minute

Then $\frac{RV}{33,000}$ = effective horse-power = $\frac{4}{10}$ indicated horse-power.

It may be assumed as approximately correct that the *Resistance varies as the square of the speed.*

If R varies as V^2, $\therefore$ RV varies as V^3 and $\therefore$ I. H. P. varies as V^3;

and since consumption of coal in a given time varies directly as the I. H. P. developed.

Consumption of coal in a given time } varies as $(\text{speed})^3$.

To find the Co-efficient of Speed.

Suppose *Agincourt* and *Northumberland* running equal distances, or equal time—say four hours—the *Agincourt* makes 5821 revolutions, and the *Northumberland* 5962; then, taking *Agincourt's* co-efficient as 1, the *Northumberland's* would be 1·024.

Therefore, for practice, if *Northumberland* is required to go the same speed as *Agincourt*—say, at forty revolutions—she would have to go $40 \times 1{\cdot}024 = 41$ (nearly) to keep station.

RULE.—Take the number of revolutions in a given time as a divisor into the number of revolutions for the same time in any other vessel—the quotient is the co-efficient.

Another approximate method is obtained by dividing the pitch of screw of any vessel by the pitch of the screw of flag-ship or leading vessel, the result being the co-efficient, which is used as before.

INSTRUCTIONS FOR ENGINE-ROOM ARTIFICERS, LEADING STOKERS, AND OTHERS IN CHARGE OF MACHINERY OF STEAM BOATS ON DETACHED SERVICE.*

For Boats with Open Stokeholds, and Fitted with Fresh-Water Tanks.

1. Fresh water, distilled water if possible, is to be used for filling and feeding the boiler. When the fire is lighted, there is not to be less than five inches of water over the top of the fire-box, which may be blown down to four inches just before getting under way, unless the boat is required for continuous steaming for some considerable time at a low power.

2. Steam is to be raised very slowly, except in cases of urgency.

3. When the fire is lighted, drain the steam pipes and cylinders, and then open the stop valves a little, to gradually warm the cylinders and cylinder jackets.

4. Lift the safety valves occasionally whilst getting up steam, and whilst under way.

5. Clear the cylinders of water before starting, and keep the jackets clear of water at all times.

6. Keep the water level in the boiler constant, and blow through the water gauge cocks occasionally.

7. Use both main feed pumps. If the pumps are not drawing, the hands of the feed pump pressure gauge will be stationary, and the hotwell will overflow; get the pumps to work by opening the pet cocks.

8. If no cocks are fitted in the feed delivery pipes, the feed pump air vessels are not to be taken off while steam is up, before it is ascertained by disconnecting the pressure gauge on the feed pipe, and opening its cock, that the non-return valve on the boiler is shut.

9. If the boiler primes, ease the engines as much as possible.

10. Fill up the fresh-water tanks at every available opportunity.

* See Admiralty Circular, No. 45 S. December, 1882.

11. Sea water is not to be used in the boiler except on emergency. When it is used, the density is not to exceed 30, and the boiler is to be opened and cleaned as soon after as possible.

12. The boiler is not to be emptied by blowing out.

13. The boiler is not to be emptied except for examination, cleaning, or repairs, and the water is to be changed as seldom as possible, while it remains clean.

14. The fire is not to be kept laid if the boiler is empty.

15. If the boat is to be used for torpedo service, the fire bars are to be secured in their places.

16. When the engines are no longer required, the cocks and valves are to be closed, and, if there is no objection, the fire is to be allowed to die out.

17. The number of hours per day that the fire is alight, is to be noted in the engine-room register of the ship to which the boat belongs.

For Boats not Fitted with Fresh-Water Tanks.

As many of the foregoing instructions as will apply, and :—

18. Great care is to be taken to prevent an accumulation of deposit in the boiler, and boiler composition is to be regularly used to prevent the formation of scale.

For Fast Torpedo Boats, and other Boats with Stokeholds under Pressure.

The following instructions are to be observed in addition to the foregoing, with the exception of paragraphs 16 *and* 18.

19. Before lighting the fire see that the smoke-box doors, the doors in the bulkheads forward and aft of the smoke-box, and the bunker covers are securely shut; and the air flaps to ash pit, and on deck, are in perfect working order.

20. As soon as there is sufficient steam, set the air pump, circulating pump, and fan engines to work slowly, and keep the stokehold hatch open to ventilate the boiler-room, and to prevent forcing the fire.

21. Keep the condenser and hotwell clear of water by the donkey; pump the water into the boiler or overboard, as required.

22. The fire bars must at all times be kept well covered with coal.

23. Prick the fire from under the bars, and great care is to be taken not to form large holes in the fire.

24. Put on fresh coal as regularly as possible, and do not keep the furnace door open longer than is absolutely necessary.

25. The air pressure must be kept as constant as possible, and is not to exceed four inches of water.

26. If the steam pressure gets too high, blow off steam into the condenser.

27. The generation of the steam is to be regulated by the speed of the fan, and not on any account by opening the furnace door.

28. Where metal rings are fitted to the pistons, the cylinders require no lubrication except at high speeds, and then very sparingly.

29. No oil is to be put into the cylinders before stopping.

30. Mineral oil is to be used for lubricating the cylinders and their glands.

31. Keep the ash pans well supplied with water where so fitted, and clear of ashes.

32. The air flaps to ash-pit fronts are on no account to be kept open, except when pricking the fire, or raking out ashes.

33. If a serious leakage occurs in the fire box, work the engines as fast as circumstances will permit, blow off steam into the condenser, and pump water into the boiler as fast as possible to reduce the pressure; keep the stokehold hatch shut and the fan working, to prevent flame coming into the stokehold; draw the fire, if practicable, and as a last resource, set the fire extinguisher to work when the men are out of the stokehold.

34. When the engines are no longer required, the steam is to be blown into the condenser, the cocks and valves closed, the iron funnel cover put on, *and the fire allowed to die out*, and care taken that the steam pressure does not rise very high with the fire remaining in the furnace.

35. Steam glands are to be packed with asbestos, and pump glands with cotton soaked in tallow.

Starting the Engine.—Have every frictional part of the engines carefully oiled, especially cylinders, slide-valves, eccentrics, cranks, and thrust: open the small drain cocks in connection with the cylinders and slide-valves, to get rid of condensed water, and let them remain open for a few turns of the engines. The steam cock may be left a little open while steam is getting up, to warm the engine. Starting ahead or astern is effected by link motion, and requires no consideration after observing the movement of the handle connected with the link.

Great care should be taken to admit the steam to the engines gently at first, and get them up to their full speed gradually.

Running.—Attention to the engines is required in preventing the overheating of working parts.

Any *unusual noise* must be quickly attended to, and cause ascertained. The loosening of pin, key, or screw, promptly remedied; always bearing in mind the old adage about "a stitch in time," etc.

The water must never be allowed to go below the mark of low level. At high speed it is liable to show higher in the gauge glass than it really is.

The gauge glass and gauge cocks must be frequently tried, the one being a check on the other. The water moving in the glass with the movements of the boat is another proof of gauge-glass cocks being correct.

Care should be taken to prevent spray from striking the gauge glass, as it is very liable to break it.

Maintain a sufficient quantity of water in the boiler, and keep the feed-water supply as nearly constant as possible. In the event of the water getting low the fire must be checked as quickly as possible; to effect this, open the smoke box door, shut the ash-pit door, and throw on wet ashes. In an extreme case, draw the fire.

When the screws of a steam launch are taken off for the purpose of her being used as a sailing boat, the brass bushes, usually provided for the purpose, should be put on the ends of the shafts (first coating them with white lead and tallow), in order to protect them from the rapid galvanic action which takes place by their close proximity to the copper sheathing on the boat's bottom. If no bushes are provided, then the ends of the shafts should be lapped round with spunyarn well saturated with stiff white lead and tallow.

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